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NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

TRANSACTIONS.

VOL. XXXIII.

NEW YORK

1883-84.

NEWCASTLE-UPON-TYNE: A. REID, PRINTING COURT BUILDINGS, AKENSIDE HILL.

1884.

'11, 2924, July 11'

NEWCASTLE-UPON-TYNE:

ANDREW REID, PRINTING COURT BUILDINGS, AKENSIDE HILL.

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Report.

YOUR Council have pleasure in reporting that the year just closed has been a fairly successful one. Considerable depression still exists in every branch of mining industry, and it would have been strange if this had not been reflected in a general way on the Institute, therefore no large increase of members or income could have been expected. In spite of this the Financial Report is a fairly average one, and the commercial aspect of the Institute is in as sound a position as ever.

Whilst the members have thus to be congratulated on the excellent financial position of the Institute, they have still more reason to be satisfied with the very valuable nature of the papers read and published, many of which have, by the minuteness of their detail and the profusion of their illustrations, assumed the position of exhaustive treatises on the subjects described. One such communication, which was read by Mr. J. D. Kendall at the meeting at Barrow in July, 1883, "On the Structure of the Cumberland Coal-field," has received additional importance from its having been discussed at Workington in March last, in the presence of almost all the engineers of the district. Here Mr. Kendall's communication was subjected to every possible criticism, and many important facts elicited which materially added to its value, and the paper with the discussion (which is still to be continued) is probably the most exhaustive treatise of the geological disposition of that part of the country that is at present published.

Mr. E. F. Melly's paper "Notes on the Warwickshire Coal-field" has filled a gap in the proceedings as far as that district is concerned, and it is satisfactory to know that, as soon as it was published, copies were eagerly sought by professional gentlemen whose vocations led them to the district.

A highly scientific and exceedingly interesting paper on "Some Results of the Observations on Underground Temperatures during the Construction of the St. Gothard Tunnel" by Dr. F. Stapff has been communicated by Professor G. A. Lebour, and is one which will probably be an authority upon the subject, and prove of eminent value when the increase of explorations in the structure of the earth will render it important that the laws regulating the increase of temperature as its centre is approached should be more thoroughly and properly understood.

Two very interesting papers have been read, one by Professor G. A. Lebour, and the other by Mr. M. Walton Brown, on some phenomena which

have been observed in the County of Durham for some years past, and which have now forced themselves more particularly into notice. These earth tremors, or "earthshakes" as they have been called, have been explained in different ways by these two gentlemen, and the discussion which will arise will no doubt be of a highly interesting nature.

Of the mechanical papers, the one by Mr. W. F. Hall, on a mode of breaking down coal without the aid of explosives, will be probably found the most interesting, since it touches a subject which is of vital importance to the profession of the miner.

Scarcely less in importance is the one by Mr. H. Lawrence on a composite metal, as a substitute for copper or brass in the manufacture of stemming gear, and which is of such a nature that it greatly diminishes the probability of giving out sparks.

Other papers of great interest have also been read but hardly call for any special notice.

The abstracts from foreign mining and mechanical papers, which it was decided some short time ago to add to the volume of proceedings, have been made this year with much care by the gentlemen entrusted with this portion of the Transactions, and will be found to contain much valuable information.

With regard to the general success of the Institute, which your Finance Committee has set forth, your Council would remark that in the abstract it is satisfactory, but they do not see any reason why in future years much more satisfactory reports should not be obtained; in a society like this, to stand still is practically a reverse.

In great industries, with ever increasing activity and extended operations, like those which this Institute represents, it should advance every year with rapid strides, and your Council feel certain that this would be the case if every existing member would bear this in mind and use his utmost endeavours to strengthen the influence of the Institute.

In conclusion, it may be interesting to the members to know that the Durham College of Science, which was founded 14 years ago, very much through the exertions of Mr. E. F. Boyd, who was then the President of the Institute, has now decided to purchase a site in the cricket field and commence building. The desire and earnest wish of the members to have a college where the sons of professional gentlemen might be educated in scientific subjects, has been so far accomplished, and the efforts that have been made for many years by the Members and Council of this Institute, have at last ripened into success.

Finance Report.

The Income for the financial year 1883-84 has been £1,991 13s., and the expenditure £1,804 1s. 1d., leaving a surplus of income over expenditure of £187 11s. 11d. The excess of income over expenditure last year was £192 6s. 4d.

The total amount of subscriptions and arrears received from all classes of members and subscribing collieries has been £1,615 17s., being £3 19s. more than the amount received last year.

Arrears still continue to form an important item in the Balance Sheet, the amount now outstanding being £468 6s., an increase of £36 15s., notwithstanding every effort that is made to diminish the amount.

There has been a decrease of 8 in the number of members, the total number of all classes on the list now being 823. This is not satisfactory though it may be accounted for by the wide-spread depression in every branch of mining and engineering, but it is still much to be desired that each individual member should use his interest and exertions to increase the usefulness of the Institute by obtaining members from his professional and other friends.

The Committee recommend that £500 of the cash at bank be invested.

G. B. FORSTER.
JOHN DAGLISH.
L. WOOD.

AWARDS FOR PAPERS WHICH HAVE APPEARED IN VOLUMES XXXI. AND XXXII. OF THE TRANSACTIONS OF THE INSTITUTE.

VOLUME XXXI.

Name.	Title of Paper.	Amount. £	s.	d.
A. L. Steavenson ...	Notes upon Messrs. Pernolet and Aguillon's "Report upon the Working and Regulation of Fiery Mines in England"	2	0	0
Charles Parkin	On Jet Mining	1	0	0
G. A. Lebour	On the Present State of our Knowledge of Underground Temperature	2	0	0
W. J. Bird	On the Comparative Efficiency of Non-conducting Coverings for Steam Pipes ...	1	0	0
Edwin Gilpin	On the Gold-fields of Nova Scotia	3	0	0
E. F. Melly	On the Anthracite Coal of South Wales ...	1	0	0
J. D. Kendall	On the Hæmatite Deposits of Furness ...	5	0	0
		15	0	0

VOLUME XXXII.

C. Tyldeu-Wright ...	On the Channel Tunnel	3	0	0
W. J. Bird	On the Comparative Efficiency of Non-conducting Coverings for Boilers and Steam Pipes	1	0	0
Charles Parkin	On the Mineral Resources of the Rosedale Abbey District	1	0	0
Charles Hunting	On the Feeding and Management of Colliery Horses	3	0	0
W. S. Gresley	On Two Systems of Working the Main Coal at Moira, in Leicestershire	1	0	0
E. B. Marten	On Explosions of Boilers and other Vessels...	2	0	0
W. Steadman Aldis ...	On Internal Stress in Cylindrical and Spherical Dams	1	0	0
V. W. Corbett	On Water-gauge, Barometer, and other Observations taken at Seaham Colliery during the Time the Maudlin Seam was sealed up	5	0	0
J. D. Kendall	On the Structure of the Cumberland Coal-field	4	0	0
		21	0	0

ADVERTISEMENT.

THE Institute is not, as a body, responsible for the facts and opinions advanced in the Papers read, and in the Abstracts of the Conversations which occurred at the Meetings during the Session.

TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND

DR. *For the Year ending*

				£	s.	d.
To Balance at Bankers				668	3	9
To Balance in hands of Treasurer				27	2	2
To Dividend of 8 per cent. on 134 Shares of £20 each = £2,680				214	8	0
To Rent of College Class Rooms, less Borough Rates				51	18	1
To Literary and Philosophical Society (Wood Memorial Hall)				4	5	0
To Interest on Investment with River Tyne Commissioners...				39	3	4
To Wood Memorial Hall...				2	2	0
To Subscriptions for 1883–4 from 436 Original Members ...			£915 12 0			
To Do. do. 1 do. paid as Life Member ...			20 0 0			
To Do. do. 24 Ordinary Members			73 10 0			
To Do. do. 1 do. paid as Life Member ...			25 0 0			
To Do. do. 96 Associate Members... ...			201 12 0			
To Do. do. 1 do. paid as Life Member ...			20 0 0			
To Do. do. 87 Students			91 7 0			
To Do. do. 2 do. paid as Associate Members			4 4 0			
To Do. do. 7 New Ordinary Members ...			22 1 0			
To Do. do. 5 New Associate Members ...			10 10 0			
To Do. do. 5 New Students...			5 5 0			
To Subscribing Collieries:—						
Ashington	£2 2 0					
Birtley Iron Company	6 6 0					
Haswell	4 4 0					
Hetton	10 10 0					
Lambton	10 10 0					
Londonderry	10 10 0					
Marquess of Bute	10 10 0					
North Hetton	6 6 0					
Ryhope	4 4 0					
Seghill	2 2 0					
South Hetton and Murton	4 4 0					
Stella	2 2 0					
Throckley	2 2 0					
Victoria Garesfield	2 2 0					
Wearmouth	4 4 0					
			81 18 0			
			1,470 19 0			
To Members' Arrears			121 16 0			
To Students' do.			12 12 0			
To Collieries' do.			10 10 0			
				1,615	17	0
To Sale of Publications, per A. Reid			54 7 10			
Less 10 per cent. Commission			5 8 9			
				48	19	1
To Sale of Publications per Secretary				15	0	6
				£2,686	18	11

INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

July 31st, 1884. Cr.

	£	s.	d.	£	s.	d.
By Paid A. Reid, Publishing Account	566	5	4			
By Do. Covers for Parts and Stitching	17	12	6			
By Do. Binding and Sewing Volumes	43	2	10			
By Do. Postage	32	5	6			
By Do. Stationery and Circulars	99	0	3			
By Do. Library	15	17	10			
				774	4	3
By other Printing and Stationery				1	1	0
By Secretary's Incidental Expenses and Postage				198	17	5
By Sundry Accounts				21	14	10
By Travelling Expenses				5	8	4
By Secretary's Salary				300	0	0
By Assistant's Do.				75	0	0
By Reporter's Do.				15	12	0
By Payments on Account of Furnishing				162	1	3
By Rent				72	18	2
By Rates and Taxes				11	13	5
By Fire Insurance				9	0	6
By Water, Coals, and Gas				24	11	7
By Books for Library in addition to Amount paid A. Reid ...				49	12	3
By Awards for Papers				29	1	6
By Abstracts of Foreign Papers				53	4	7
By Balance at Bankers				785	11	8
By Balance in hands of Treasurer				97	6	2
				£2,686	18	11

Audited and Certified,

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Newcastle-on-Tyne,

2nd August, 1884.

DR. THE TREASURER IN ACCOUNT

		£	s.	d.
To 533 Original Members, as per List 1883-84.				
10 of whom are Life Members.				
523				
1 having paid as a Life Member		20	0	0
522 @ £2 2s....		1,096	4	0
To 33 Ordinary Members, as per List 1883-84.				
1 of which is a Life Member.				
32				
1 having paid as a Life Member		25	0	0
31 29 @ £3 3s., and 2 @ £2 2s.		95	11	0
To 119 Associate Members, as per List 1883-84.				
5 of whom are Life Members.				
114				
1 having paid as a Life Member.		20	0	0
113 @ £2 2s.		237	6	0
To 112 Students as per List 1883-84.				
2 paid as Associates		4	4	0
110 @ £1 1s.		115	10	0
To 15 Subscribing Collieries		81	18	0
To 8 New Ordinary Members @ £3 3s.		25	4	0
To 9 New Associate Members @ £2 2s.		18	18	0
To 5 New Students @ £1 1s.		5	5	0
		1,745	0	0
To Arrears, as per last Balance Sheet	£431 11 0			
Deduct—				
To Irrecoverable 1883-84 List	92 8 0			
		339	3	0
		£2,084	3	0

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WITH SUBSCRIPTIONS, 1883-84. CR.

		PAID. £ s. d.	UNPAID. £ s. d.
By 436	Original Members paid @ £2 2s.	915 12 0	
By 67	Do. unpaid		140 14 0
By 9	Do. dead, unpaid		18 18 0
By 3	Do. resigned, unpaid		6 6 0
By 6	Do. gone, no address		12 12 0
By 1	Do. struck off		2 2 0
522			
By 1	Do. paid as Life Member	20 0 0	
By 22	Ordinary Members paid @ £3 3s.	69 6 0	
By 2	Do. paid @ £2 2s.	4 4 0	
By 7	Do. unpaid		22 1 0
31			
By 1	Do. paid as Life Member	25 0 0	
By 96	Associate Members paid @ £2 2s.	201 12 0	
By 16	Do. unpaid		33 12 0
By 1	Do. gone, no address		2 2 0
113			
1	Do. paid as Life Member	20 0 0	
By 87	Students paid @ £1 1s.	91 7 0	
By 21	Do. unpaid		22 1 0
By 2	Do. gone, no address		2 2 0
110			
2	Do. paid as Associates	4 4 0	
By 15	Subscribing Collieries paid	81 18 0	
By 7	New Ordinary Members paid at £3 3s.	22 1 0	
By 1	Do. unpaid		3 3 0
8			
By 5	New Associate Members paid at £2 2s.	10 10 0	
By 4	Do. unpaid		8 8 0
9			
By 5	New Students paid @ £1 1s.	5 5 0	
		1,470 19 0	274 1 0
By Members' Arrears paid	... ...	121 16 0	182 14 0
By Students' Do.	... ...	12 12 0	11 11 0
By Collieries Do.	... ...	10 10 0	
		1,615 17 0	468 6 0
			1,615 17 0
			£2,084 3 0

Dr. GENERAL STATEMENT, AUGUST, 1884. Cr.

Liabilities.	£	s.	d.
None	„	„	„
Capital	10,961	10	10
	£10,961	10	10

Audited and Certified,
(Share Certificates and Bond produced),
JOHN G. BENSON,
Chartered Accountant.

Newcastle-upon-Tyne,
2nd August. 1884.

Assets.				£	s.	d.
Balance of Account at Bankers	785	11	8			
Balance in hands of Treasurer	97	6	2			
				882	17	10
134 Shares of £20 each in the Institute and Coal Trade Chambers Company (Limited)...				2,680	0	0
Invested with River Tyne Commissioners...				1,000	0	0
Arrears of Subscriptions				468	6	0
Value of 375 Bound Volumes of Transactions, @ 11s. 6d.				215	12	6
Value of 4,138 Sewn Copies of Transactions, @ 9s. ...				1,862	2	0
Value of Sundry Sheets and Plates belonging to Vol. XXXIII., unfinished at this date				237	0	0
Value of 37 Copies of Mr. T. F. Brown's Map of the South Wales Coal-field, @ 5s....				9	5	0
Value of 390 Copies of General Index, @ 3s.				58	10	0
Value of 755 Copies of Fossil Illustrations, @ 12s. 6d. ...				471	17	6
Value of 884 Copies of Fossil Catalogue, at 5s.				221	0	0
Value of 840 Copies of Borings and Sinkings, Vol. I., @ 5s.				210	0	0
Value of 348 Copies of Borings and Sinkings, Vol. II., @ 5s.				87	0	0
Value of 1.500 Vols. of Borings and Sinkings, in Sheets				300	0	0
Value of Sundry Sheets of Borings and Sinkings belonging to Vol. III., unfinished at this date				108	0	0
Value of Furniture and Office Fittings				450	0	0
Value of Books and Maps in Library				1,700	0	0
				£10,961	10	10

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A. M. POTTER, Esq., Shire Moor Colliery, Northumberland.
H. RICHARDSON, Esq., Backworth Colliery, Newcastle-on-Tyne.
R. ROBINSON, Esq., Howlish Hall, near Bishop Auckland.
J. G. WEEKS, Esq., Bedlington Collieries, Bedlington.
J. WILLIS, Esq., 14, Portland Terrace, Newcastle-on-Tyne.

Ex-officio

Past Presidents:
SIR W. G. ARMSTRONG, C.B., LL.D., F.R.S., Jesmond, Newcastle-on-Tyne.
E. F. BOYD, Esq., F.G.S., Moor House, Leamside, Fence Houses.
SIR GEORGE ELLIOT, Bart., M.P., Houghton Hall, Fence Houses.
LINDSAY WOOD, Esq., Southill, Chester-le-Street.
G. C. GREENWELL, Esq., F.G.S., Elm Tree Lodge, Duffield, Derby.
G. B. FORSTER, Esq., M.A., Lesbury, R.S.O., Northumberland.

Retiring Vice-Presidents:
W. ARMSTRONG, Esq., Pelaw House, Chester-le-Street.
J. DAGLISH, Esq., Marsden, South Shields.
T. DOUGLAS, Esq., Peases' West Collieries, Darlington.

Secretary and Treasurer.

THEO. WOOD BUNNING, Neville Hall. Newcastle-on-Tyne.

List of Members.

AUGUST, 1884.

Original Members.

Marked * are Life Members.

		ELECTED
1	ADAMS, G. F., Guild Hall Chambers, Cardiff	Dec. 6, 1873
2	ADAMS, W., Cambridge House, Park Place, Cardiff	1854
3	ADAMSON, DANIEL, Engineering Works, Dukinfield, near Manchester	Aug. 7, 1875
4	AITKIN, HENRY, Falkirk, N.B.	Mar. 2, 1865
5	ALLISON, T., Belmont Mines, Guisbro'	Feb. 1, 1868
6	ANDERSON, C. W., Cleadon House, Harrogate	Aug. 21, 1852
7	ANDERSON, WILLIAM, Rainton Colliery, Fence Houses	Aug. 21, 1852
8	ANDREWS, HUGH, Felton Park, Felton, Northumberland	Oct. 5, 1872
9	APPLEBY, C. E., Charing Cross Chambers, Duke St., Adelphi, London	Aug. 1, 1861
10	ARCHER, T., Dunston Engine Works, Gateshead	July 2, 1872
11	ARMSTRONG, SIR W. G., C.B., LL.D., F.R.S., Jesmond, Newcastle-upon-Tyne ... ... (PAST PRESIDENT, *Member of Council*)	May 3, 1866
12	ARMSTRONG, WM., Pelaw House, Chester-le-Street (RETIRING VICE-PRESIDENT, *Member of Council*)	Aug. 21, 1852
13	ARMSTRONG, W., Jun., Wingate, Co. Durham	April 7, 1867
14	ARMSTRONG, W. L., Oaklands Rock, near Bewdley	Mar. 3, 1864
15	ARTHUR, DAVID, M.E., Accrington, near Manchester	Aug. 4, 1877
16	ASHWORTH, JAMES, Mapperley Colliery, West Hallam, Derby ...	Feb. 5, 1876
17	ASHWORTH, JOHN, Hanover Chambers, King Street, Manchester ...	Sept. 2, 1876
18	ASQUITH, T. W., Seaton Delaval Colliery, Northumberland	Feb. 2, 1867
19	ATKINSON, J. B., Ridley Mill, Stocksfield-on-Tyne	Mar. 5, 1870
20	ATKINSON, W. N., Shincliffe Hall, Durham (*Member of Council*) ...	June 6, 1868
21	AUBREY, R. C., Wigan Coal & Iron Co. Ld., Standish, near Wigan ...	Feb. 5, 1870
22	AUSTINE, JOHN, Cadzow Coal Co., Glasgow	Nov. 4, 1876
23	AYNSLEY, WM., Brynkinalt Collieries, Chirk, Ruabon	Mar. 3, 1873
24	BAILES, GEORGE, Murton Colliery, Sunderland	Feb. 3, 1877
25	BAILES, JOHN, Wingate Colliery, Ferryhill	Sept. 5, 1868
26	BAILES, T., 6, Collingwood Terrace, Jesmond Gardens, Newcastle ...	Oct. 7, 1858
27	BAILES, W., West Melton, Rotherham	April 7, 1877
28	BAILEY, SAMUEL, Perry Barr, Birmingham	June 2, 1859
29	BAIN, R. DONALD, Newport, Monmouthshire	Mar. 3, 1873

		ELECTED.
30	BAINBRIDGE, E., Nunnery Colliery Offices, Sheffield	Dec. 3, 1863
31	BANKS, THOMAS, Leigh, near Manchester	Aug. 4, 1877
32	BARCLAY, A., Caledonia Foundry, Kilmarnock	Dec. 6, 1866
33	BARNES, T., Seaton Delaval Office, Quay, Newcastle-on-Tyne ...	Oct. 7, 1871
34	BARRAT, A. J.	Sept. 11, 1875
35	BARTHOLOMEW, C., Castle Hill House, Ealing, London, W.	Aug. 5, 1853
36*	BARTHOLOMEW, C. W., Blakesley Hall, near Towcester	Dec. 4, 1875
37	BASSETT, A., Tredegar Mineral Estate Office, Cardiff	1854
38	BATES, MATTHEW, Bews Hill, Blaydon-on-Tyne	Mar. 3, 1873
39	BATES, W. J., Old Axwell, Whickham, Gateshead-on-Tyne	Mar 3, 1873
40	BATEY, JOHN, Newbury Collieries, Coleford, Bath	Dec. 5, 1868
41	BEANLANDS, A., M.A., North Bailey, Durham	Mar. 7, 1867
42	BEAUMONT, JAMES, M.E., Nanaimo, Vancouver's Island	Nov. 7, 1874
43	BELL, I. LOWTHIAN, Rounton Grange, Northallerton (VICE-PRESIDENT)	July 6, 1854
44	BELL, JOHN, Messrs. Bell Brothers, Middlesbro'-on-Tees	Oct. 1, 1857
45	BENSON, J. G., Accountant, 12, Grey Street, Newcastle-on-Tyne ..	Nov. 7, 1874
46	BENSON, T. W., 11, Newgate Street, Newcastle *(Member of Council)*	Aug. 2, 1866
47	BERKLEY, C., Marley Hill, Whickham R.S.O., Co. Durham	Aug. 21, 1852
48	BEWICK, T. J., M.I.C.E., F.G.S., Haydon Bridge, Northumberland (VICE-PRESIDENT)	April 5, 1860
49	BIDDER, B. P.	May 2, 1867
50	BIGLAND, J., Bedford Lodge, Bishop Auckland	June 4, 1857
51	BINNS, C., Claycross, Derbyshire	July 6, 1854
52	BIRAM, B., Peaseley Cross Collieries, St. Helen's, Lancashire ...	1856
53	BLACK, JAMES, Jun., Portobello Foundry, Sunderland	Sept. 2, 1871
54	BLACK, W., Hedworth Villa, South Shields	April 2, 1870
55	BOLTON, H. H., Newchurch Collieries, near Manchester	Dec. 5, 1868
56	BOOTH, R. L., Ashington Colliery, near Morpeth	1864
57	BOURNE, THOS. W., Babbington Coal Co., Nottingham	Sept. 11, 1875
58	BOYD, E. F., Moor House, Leamside, Fence Houses (PAST PRESIDENT, *Member of Council*)	Aug. 21, 1852
59	BOYD, R. F., Moor House, Leamside, Fence Houses	Nov. 6, 1869
60	BOYD, WM., 74, Jesmond Road, Newcastle-on-Tyne *(Member of Council)*	Feb. 2, 1867
61	BRECKON, J. R., 32, Fawcett Street, Sunderland	Sept. 3, 1864
62	BRETTELL, T., Mine Agent, Dudley, Worcestershire	Nov. 3, 1866
63	BROMILOW, WM., 18, Leicester Street, Southport, Lancashire ...	Sept. 2, 1876
64	BROWN, JOHN, Priory Place, 155, Bristol Road, Birmingham ...	Oct. 5, 1854
65	BROWN, J. N., 56, Union Passage, New Street, Birmingham ...	1861
66	BROWN THOS. FORSTER, Guild Hall Chambers, Cardiff	1861
67	BROWNE, B. C., M.I.C.E., 2, Granville Road, Jesmond, Newcastle ...	Oct. 1, 1870
68	BRYHAM, WILLIAM, Rosebridge Colliery, Wigan	Aug. 1, 1861
69	BRYHAM, W., Jun., Douglas Bank Collieries, Wigan	Aug. 3, 1865
70	BUNNING, THEO. WOOD, Neville Hall, Newcastle-on-Tyne *(Secretary and Treasurer)*	1864
71*	BURNS, DAVID, C.E., Clydesdale Bank Buildings, Bank St., Carlisle...	May 5, 1877
72	BURROWS, J. S., Yew Tree House, Atherton, near Manchester ...	Oct. 11, 1873

ELECTED.

73 CAMPBELL, W. B., Consulting Engineer, Grey Street, Newcastle ... Oct. 7, 1876
74 CARR, WM. COCHRAN, South Benwell, Newcastle-on-Tyne ... ... Dec. 3, 1857
75 CHADBORN, B. T., Pinxton Collieries, Alfreton, Derbyshire 1864
76 CHAMBERS, A. M., Thorncliffe Iron Works, near Sheffield ... ... Mar. 6, 1869
77 CHEESMAN, I., Throckley Colliery, Newcastle-on-Tyne ... ... Feb. 1, 1873
78 CHEESMAN, W. T., Wire Rope Manufacturer, Hartlepool ... ... Feb. 5, 1876
79 CHILDE, ROWLAND, Wakefield, Yorkshire ... ... May 15, 1862
80 CLARENCE, THOMAS, 10, Bentinck Crescent, Newcastle-on-Tyne ... Dec. 4, 1875
81 CLARK, C. F., Garswood Coal and Iron Co., near Wigan ... ... Aug. 2, 1866
82 CLARK, R. B., Marley Hill, near Gateshead ... ... May 3, 1873
83 CLARK, W., M.E., The Grange, Teversall, near Mansfield ... ... April 7, 1866
84 CLARKE, WILLIAM, Victoria Engine Works, Gateshead ... ... Dec. 7, 1867
85 COCHRANE, B., Aldin Grange, Durham ... ... Dec. 6, 1866
86 COCHRANE, C., The Grange, Stourbridge ... ... June 3, 1857
87 COCHRANE, W., St. John's Chambers, Grainger Street West, Newcastle (VICE-PRESIDENT) 1859
88 COLE, RICHARD, Walker Colliery, near Newcastle-on-Tyne ... . April 5, 1873
89 COLE, ROBERT HEATH, Lord Street, Basford, Stoke-upon-Trent ... Feb. 5, 1876
90 COLLIS, W. B., Swinford House, Stourbridge, Worcestershire ... June 6, 1861
91 COOK, J., Jun., Washington Iron Works, Gateshead ... ... May 8, 1869
92 COOKE, JOHN, 3, Cross Street, Durham ... ... Nov. 1, 1860
93 COOKSEY, JOSEPH, West Bromwich, Staffordshire ... ... Aug. 3, 1865
94 COOPER, P., Thornley Colliery Office, Ferryhill... ... ... Dec. 3, 1857
95 COOPER, R. E., C.E., 8, The Sanctuary, Westminster, London, S.W.... Mar. 4, 1871
96 COOPER, T., Rosehill, Rotherham, Yorkshire ... ... April 2, 1863
97 COPE, JAMES, 9 and 10, Glebe Buildings, Stoke-upon-Trent ... ... Oct. 5, 1872
98 CORBETT, V. W., Chilton Moor, Fence Houses ... ... Sept. 3, 1870
99 CORBITT, M., Wire Rope Manufacturer, Teams, Gateshead ... ... Dec. 4, 1875
100 COULSON, F., 10, Victoria Terrace, Durham ... ... Aug. 1, 1868
101 COULSON, W., 32, Crossgate, Durham ... ... Oct. 1, 1852
102 COWEN, JOS., M.P., Blaydon Burn, Newcastle-on-Tyne ... ... Oct. 5, 1854
103 COWEY, JOHN, Wearmouth Colliery, Sunderland ... ... Nov. 2, 1872
104 COX, JOHN H., 10, St. George's Square, Sunderland ... ... Feb. 6, 1875
105*COXE, E. B., Drifton, Jeddo, P. O. Luzerne Co., Penns., U.S. ... Feb. 1, 1873
106 COXON, S. B., 23, Great George Street, Westminster, London ... June 5, 1856
107 CRAIG, W. Y., Palace Chambers, St. Stephen's, Westminster, London Nov. 3, 1866
108 CRAWFORD, T., Littletown Colliery, near Durham ... ... Aug. 21, 1852
109 CRAWFORD, T., 3, Grasmere Street, Gateshead-on-Tyne ... ... Sept. 3, 1864
110 CRAWFORD, T., Jun. Littletown Colliery, near Durham ... ... Aug. 7, 1869
111 CRAWSHAY, E., Gateshead-on-Tyne ... ... Dec. 4, 1869
112 CRAWSHAY, G., Gateshead-on-Tyne ... ... Dec. 4, 1869
113 CRONE, E. W., Killingworth Hall, near Newcastle-on-Tyne ... ... Mar. 5, 1870
114 CRONE, J. R., Tudhoe House, *via* Spennymoor ... ... Feb. 1, 1868
115 CRONE, S. C., Killingworth Hall, Newcastle *(Member of Council)* ... 1853
116 CROSS, JOHN, 77, King Street, Manchester ... ... June 5, 1869
117 CROUDACE, C. J., Bettisfield Colliery Co., Limited, Bagillt, N. Wales Nov. 2, 1872

ELECTED.

118 CROUDACE, JOHN, West House, Haltwhistle ... ... June 7, 1873
119 CROUDACE, THOMAS, Lambton Lodge, New South Wales 1862

120 DAGLISH, JOHN, Marsden, South Shields (PRESIDENT) ... ... Aug. 21, 1852
121 DAGLISH, W. S., Solicitor, Newcastle-on-Tyne ... ... July 2, 1872
122 DAKERS, J., Chilton Colliery, Ferryhill ... ... April 11, 1874
123 DALE, DAVID, West Lodge, Darlington ... ... Feb. 5, 1870
124 D'ANDRIMONT, T., Liége, Belgium ... ... Sept. 3, 1870
125 DANIEL, W., Steam Plough Works, Leeds ... ... June 4, 1870
126 DARLING, FENWICK, South Durham Colliery, Darlington ... ... Nov. 6, 1875
127 DARLINGTON, JAMES, Black Park Colliery Co. Limited, Ruabon ... Nov. 7, 1874
128 DARLINGTON, JOHN, 2, Coleman Street Buildings, Moorgate Street, Great Swan Alley, London ... ... April 1, 1865
129 DAVEY, HENRY, C.E., Leeds ... ... Oct. 11, 1873
130 DAVIS, DAVID, Coal Owner, Maesyffynon, Aberdare ... ... Nov. 7, 1874
131 DAY, W. H. ... ... Mar. 6, 1869
132 DEES, R. R., Solicitor, Newcastle-on-Tyne ... ... Oct. 7, 1871
133 DICKINSON, G. T. ... ... July 2, 1872
134 DICKINSON, R., Coal Owner, Shotley Bridge, Co. Durham ... ... Mar. 4, 1871
135 DIXON, D. W., Lumpsey Mines, Brotton, Saltburn-by-the-Sea ... Nov. 2, 1872
136 DIXON, NICH., Dudley Colliery, Dudley, Northumberland ... ... Sept. 1, 1877
137 DIXON, R., Wire Rope Manufacturer, Teams, Gateshead ... ... June 5, 1875
138 DODD, B., Bearpark Colliery, near Durham ... ... May 3, 1866
139 DODDS, JOSEPH, M.P., Stockton-on-Tees ... ... Mar. 7, 1874
140 DOUGLAS, C. P., Parliament Street, Consett, Co. Durham ... ... Mar. 6, 1869
141 DOUGLAS, T., Peases' West Collieries, Darlington (RETIRING VICE-PRESIDENT, *Member of Council*) ... ... Aug. 21, 1852
142 DOVE, G., Viewfield, Stanwix, Carlisle ... ... July 2, 1872
143 DOWDESWELL, H., Butterknowle Colliery, *via* Darlington ... ... April 5, 1873
144 DYSON, GEORGE, Middlesborough ... ... June 2, 1866
145 DYSON, O., Pooley Hall Colliery, near Tamworth ... ... Mar. 2, 1872

146 EDDISON, ROBERT W., Steam Plough Works, Leeds ... ... Mar. 4, 1876
147 ELLIOT, SIR GEORGE, Bart., M.P., Houghton Hall, Fence Houses (PAST PRESIDENT, *Member of Council*) ... ... Aug. 21, 1852
148 ELSDON, ROBERT, 76, Manor Road, Upper New Cross, London ... Nov. 4, 1876
149 EMBLETON, T. W., The Cedars, Methley, Leeds ... ... Sept. 6, 1855
150 EMBLETON, T. W., Jun., The Cedars, Methley, Leeds ... ... Sept. 2, 1865
151 EMINSON, J. B., Londonderry Offices, Seaham Harbour ... ... Mar. 2, 1872
152 EVERARD, I. B., M.E., 6, Millstone Lane, Leicester ... ... Mar. 6, 1869

153 FARMER, A., South Durham Fitting Offices, West Hartlepool ... Mar. 2, 1872
154 FARRAR, JAMES, Old Foundry, Barnsley ... ... July 2, 1872
155 FAVELL, THOMAS M., Etruria Iron Works, near Stoke-on-Trent ... April 5, 1873
156 FENWICK, BARNABAS, 84, Osborne Road, Newcastle-on-Tyne ... Aug. 2, 1866
157 FERENS, ROBINSON, Oswald Hall, near Durham ... ... April 7, 1877
158 FIDLER, E., Platt Lane Colliery, Wigan, Lancashire ... ... Sept. 1, 1866
159 FISHER, R. C., 5, Picton Place, Swansea ... ... July 2, 1872

ELECTED.

160 FLETCHER, GEO. ... ... Aug. 1, 1874
161 FLETCHER, H., Ladyshore Coll., Little Lever, Bolton, Lancashire ... Aug. 3, 1865
162 FLETCHER, JAS., Manager Co-operative Collieries, Wallsend, near Newcastle, New South Wales ... ... Sept. 11, 1875
163 FLETCHER, JOHN, 79, Newby Street, Walton Lane, Liverpool ... July 2, 1872
164 FOGGIN, WM., North Biddick Coll., Washington Station, Co. Durham Mar. 6, 1875
165 FORREST, J., Ass. I.C.E., Witley Coll., Halesowen, Birmingham ... Mar. 5, 1870
166 FORSTER, G. B., M.A., Lesbury, R.S.O., Northumberland (PAST PRESIDENT, *Member of Council*) ... ... Nov. 5, 1852
167 FORSTER, J. R., Water Company's Office, Newcastle-on-Tyne ... July 2, 1872
168 FORSTER, J. T., Burnhope Colliery, near Lanchester, Co. Durham ... Aug. 1, 1868
169 FORSTER, R., South Hetton, Fence Houses ... ... Sept. 5, 1868
170 FOSTER, GEORGE, Osmondthorpe Colliery, near Leeds ... ... Mar. 7, 1874
171 FRANCE, FRANCIS, St. Helen's Colliery Co. Ld., St. Helen's, Lancashire Sept. 1, 1877
172 FRANCE, W., Lofthouse Mines, Loftus-in-Cleveland R.S.O. ... ... April 6, 1867
173 FRANKS, GEORGE, Victoria Garesfield, Lintz Green, Newcastle-on-Tyne Feb. 6, 1875
174 GALLOWAY, T. LINDSAY, M.A., Argyle Colliery, Campbeltown, N.B. Sept. 2, 1876
175 GERRARD, JOHN, Westgate, Wakefield ... ... Mar. 5, 1870
176 GILLETT, F. C., Midland Road, Derby ... ... July 4, 1861
177 GILMOUR, D., Portland Colliery, Kilmarnock ... ... Feb. 3, 1872
178 GILPIN, EDWIN, 75, Birmingham Street, Halifax, Nova Scotia ... April 5, 1873
179 GILROY, G., Ince Hall Colliery, Wigan, Lancashire ... ... Aug. 7, 1856
180 GILROY, S. B., Mining Engineer, Cheatham Hill, Manchester ... Sept. 5, 1868
181 GJERS, JOHN, Southfield Villas, Middlesbro' ... ... June 7, 1873
182 GODDARD, F. R., Accountant, Newcastle-on-Tyne ... ... Nov. 7, 1874
183 GORDON, JAMES N., c/o W. Nicolson, 5, Jeffrey's Square, St. Mary Axe, London, E.C. ... ... Nov. 6, 1875
184 GRACE, E. N., Dhadka, Assensole, Bengal, India ... ... Feb. 1, 1868
185 GRANT, J. H., District Engineer, Beerbhoon, Bengal, India ... ... Sept. 4, 1869
186 GREAVES, J. O., St. John's, Wakefield ... ... Aug. 7, 1862
187 GREEN, J. T., Mining Engineer, Ty Celyn, Abercarn, Newport, Mon. Dec. 3, 1870
188 GREENER, JOHN, General Manager, Vale Coll., Pictou, Nova Scotia ... Feb. 6, 1875
189 GREENWELL, G. C., Elm Tree Lodge. Duffield, Derby (PAST PRESIDENT, *Member of Council*) ... ... Aug. 21, 1852
190 GREENWELL, G. C., Jun., Poynton, near Stockport *(Member of Council)* Mar. 6, 1869
191 GREIG, D., Leeds ... ... Aug. 2, 1866
192 GREY, C. G., 55, Parliament Street, London ... ... May 4, 1872
193 GRIEVES, D., Brancepeth Colliery, Willington, County Durham ... Nov. 7, 1874
194 GRIFFITH, N. R., Wrexham 1866
195 GRIMSHAW, E. J., 23, Hardshaw Street, St. Helen's, Lancashire ... Sept. 5, 1868
196 HAGGIE, D. H., Wearmouth Patent Rope Works, Sunderland ... Mar. 4, 1876
197 HAGGIE, P., Gateshead 1854
198* HAGUE, ERNEST, Castle Dyke, Sheffield ... ... Mar. 2, 1872
199 HAINES, J. RICHARD, Adderley Green Colliery, near Longton ... Nov. 7, 1874
200 HALES, C., Nerquis Cottage, Nerquis, near Mold, Flintshire 1865
201 HALL, M., Lofthouse Station Collieries, near Wakefield . ... Sept. 5, 1868

		ELECTED.
202	HALL, M. S., Leasingthorne Colliery, near Bishop Auckland ...	Feb. 14, 1874
203	HALL, WM., East Hetton Colliery Office, Coxhoe, Co. Durham	Dec. 4, 1875
204	HALL, WILLIAM F., Haswell Colliery, Fence Houses	May 13, 1858
205	HANN, EDMUND, Aberaman, Aberdare	Sept. 5, 1868
206	HARBOTTLE, W. H., Orrell Colliery, near Wigan	Dec. 4, 1875
207	HARDY, JOS.	June 2, 1877
208	HARGREAVES, WILLIAM, Rothwell Haigh, Leeds	Sept. 5, 1868
209	HARLE, RICHARD, Browney Colliery, Durham	April 7, 1877
210	HARLE, WILLIAM, Pagebank Colliery, near Durham	Oct. 7, 1876
211	HARRISON, R., Eastwood, near Nottingham	1861
212	HARRISON, T. E., C.E., Central Station, Newcastle-on-Tyne ...	May 6, 1853
213	HARRISON, W. B., Brownhills Collieries, near Walsall ...	April 6, 1867
214	HAY, J., Jun., Widdrington Colliery, Acklington	Sept. 4, 1869
215	HECKELS, MATTHEW, Walker Colliery, Newcastle-on-Tyne ...	April 11, 1874
216	HECKELS, W. J., Evenwood, Bishop Auckland	May 2, 1868
217	HEDLEY, J. J., Consett Collieries, Leadgate, County Durham	April 6, 1872
218	HEDLEY, J. L., Flooker's Brook, Chester	Feb. 5, 1870
219	HEDLEY, T. F., Valuer, Sunderland	Mar. 4, 1871
220	HEDLEY, W. H., Consett Collieries, Medomsley, Newcastle-on-Tyne *(Member of Council)*	1864
221	HENDERSON, H., Pelton Colliery, Chester-le-Street	Feb. 14, 1874
222	HEPPELL, T., Leafield House, Birtley, Chester-le-Street *(Member of Council)*	Aug. 6, 1863
223	HEPPELL, W., Western Hill, Durham	Mar. 2, 1872
224	HERDMAN, J., Park Crescent, Bridgend, Glamorganshire ...	Oct. 4, 1860
225	HESLOP, C., Lingdale Mines, *via* Skelton, R.S.O., Yorks. ...	Feb. 1, 1868
226	HESLOP, GRAINGER, Whitwell Colliery, Sunderland	Oct. 5, 1872
227	HESLOP, J., Hucknall Torkard Colliery, near Nottingham ...	Feb. 6, 1864
228	HETHERINGTON, D., Coxlodge Colliery, Newcastle-on-Tyne	1859
229*	HEWITT, G. C., Coal Pit Heath Colliery, near Bristol ...	June 3, 1871
230	HEWLETT, A., Haigh Colliery, Wigan, Lancashire	Mar. 7, 1861
231	HIGSON, JACOB, 94, Cross Street, Manchester	1861
232*	HILTON, J., Wigan Coal and Iron Co., Limited, Wigan ...	Dec 7, 1867
233	HILTON, T. W., Wigan Coal and Iron Co., Limited, Wigan ...	Aug. 3, 1865
234	HINDMARSH, THOMAS, Cowpen Lodge, Blyth, Northumberland	Sept. 2, 1876
235	HODGSON, J. W., Dipton Colliery, *via* Lintz Green Station ...	Feb. 5, 1870
236	HOLLIDAY, MARTIN F., Langley Grove, near Durham... ...	May 1, 1875
237	HOLMES, C., Grange Hill, near Bishop Auckland	April 11, 1874
238	HOMER, CHARLES J., Mining Engineer, Stoke-on-Trent ...	Aug. 3, 1865
239	HOOD, A., 6, Bute Crescent, Cardiff	April 18, 1861
240	HOPE, GEORGE, Newbottle Colliery, Fence Houses	Feb. 3, 1877
241	HORNSBY, H., Hamsteels Colliery, near Durham	Aug. 1, 1874
242	HORSLEY, W., Whitehill Point, Percy Main, Newcastle-on-Tyne	Mar. 5, 1857
243	HOSKOLD, H. D., C. and M.E., F.R.G.S., F.G.S., M. Soc. A., &c.	April 1, 1871
244	HOWARD, W. F., 13, Cavendish Street, Chesterfield	Aug. 1, 1861
245	HUDSON, JAMES, Albion Mines, Pictou, Nova Scotia	1862
246	HUMBLE, JOHN, West Pelton, Chester-le-Street	Mar. 4, 1871

		ELECTED.
247	HUMBLE, JOS., Staveley Works, near Chesterfield	June 2, 1866
248	HUNTER, J., Silkstone and Worsbro' Park Collieries, near Barnsley ...	Mar. 6, 1869
249	HUNTER, W., Monk Bretton Colliery, near Barnsley	Oct. 3, 1861
250	HUNTER, W. S., 34, Grey Street, Newcastle-on-Tyne	Feb. 1, 1868
251	HUNTING, CHARLES, Fence Houses	Dec. 6, 1866
252	HURST, T. G., F.G.S., Osborne Road, Newcastle-on-Tyne	Aug. 21, 1852
253	JACKSON, C. G., Chamber Colliery Co.. Limited, Hollinwood	June 4, 1870
254	JACKSON, W., Cannock Chase Collieries, Walsall	Feb. 14, 1874
255	JACKSON, W. G., Loscoe Grange, Normanton, Yorkshire	June 7, 1873
256	JARRATT, J., Houghton Main Colliery, near Barnsley	Nov. 2, 1867
257	JEFFCOCK, T. W., 18, Bank Street, Sheffield	Sept. 4, 1869
258	JENKINS, W., M.E., Ocean S.C. Colls., Ystrad, nr. Pontypridd, So. Wales	Dec. 6, 1862
259	JENKINS, WM., Consett Iron Works, Consett, Durham	May 2, 1874
260	JOHNSON, HENRY, Dudley, Worcestershire	Aug. 7, 1869
261	JOHNSON, JOHN, M.I.C.E., F.G.S., 21, Grainger St. W., Newcastle	Aug 21, 1852
262	JOHNSON, J., Carlton Main Colliery, Barnsley	Mar. 7, 1874
263	JOHNSON, R. S., Sherburn Hall, Durham	Aug. 21, 1852
264	JOICEY, J. G., Forth Banks West Factory, Newcastle-on-Tyne ...	April 10, 1869
265	JOICEY, W. J., Urpeth Lodge, Chester-le-Street	Mar. 6, 1869
266	JOSEPH, D. D., Ty Draw, Pontypridd, South Wales	April 6, 1872
267	KENDALL, JOHN D., Roper Street, Whitehaven	Oct. 3, 1874
268	KIMPTON, J. G., 40, St. Mary's Gate, Derby	Oct. 5, 1872
269	KIRKBY, J. W., Ashgrove, Windygates, Fife	Feb. 1, 1873
270	KNOWLES, A., Swinton Old Hall, Manchester	Dec. 5, 1856
271	KNOWLES, JOHN, Westwood, Pendlebury, Manchester	Dec. 5, 1856
272	LAMB, R., Bowthorn Colliery, Cleator Moor, near Whitehaven ...	Sept. 2, 1865
273	LAMB, R. O., The Lawn, Ryton-on-Tyne	Aug. 2, 1866
274	LAMB, RICHARD W., Coal Owner, Newcastle-on-Tyne...	Nov. 2, 1872
275	LAMBERT, M. W., 9, Queen Street, Newcastle-on-Tyne	July 2, 1872
276	LANCASTER, JOHN, Frankfort House, Fitzjohn's Avenue, London, N.W.	Mar. 2, 1865
277	LANDALE, A., Lochgelly Iron Works, Fifeshire, N.B.	Dec. 2, 1858
278*	LAPORTE, HENRY, M.E., 80, Rue Royale, Brussels	May 5, 1877
279	LAVERICK, ROBT., West Rainton, Fence Houses	Sept. 2, 1876
280	LAWRENCE, HENRY, Grange Iron Works, Durham *(Mem. of Council)*	Aug. 1, 1868
281	LAWS, H., Grainger Street W., Newcastle-on-Tyne	Feb. 6, 1869
282	LEBOUR, G. A., M.A., F.G.S., Durham College of Science, Newcastle, *(Member of Council)*	Feb. 1, 1873
283	LEE, GEORGE, Great Ayton, *viâ* Northallerton	June 4, 1870
284	LESLIE, ANDREW, Hebburn, Gateshead-on-Tyne	Sept. 7, 1867
285	LEVER, ELLIS, Bowdon, Cheshire	1861
286	LEWIS, HENRY, Annesley Colliery, near Nottingham	Aug. 2, 1866
287	LEWIS, W. H., 3, Bute Crescent, Cardiff	Aug. 4, 1877
288	LEWIS, WILLIAM THOMAS, Mardy, Aberdare	1864
289	LIDDELL, G. H., Somerset House, Whitehaven	Sept. 4, 1869
290	LINDOP, JAMES, Bloxwich, Walsall, Staffordshire	Aug. 1, 1861

		ELECTED.
291	LINSLEY, R., Cramlington Colliery, Northumberland	July 2, 1872
292	LINSLEY, S. W., Whitburn Colliery, Sunderland	Sept. 4, 1869
293	LISHMAN, T., Jun., Hetton Colliery, Fence Houses	Nov. 5, 1870
294	LISHMAN, WM., Witton-le-Wear...	1857
295	LISHMAN, WM., Bunker Hill, Fence Houses	Mar. 7, 1861
296	LIVESEY, C., Bradford Colliery, near Manchester	Aug. 3, 1865
297	LIVESEY, T., Bradford Colliery, near Manchester	Nov. 7, 1874
298	LLEWELYN, L., 2, Clarence Place, Newport, Monmouth	May 4, 1872
299	LOGAN, WILLIAM, Langley Park Colliery, Durham	Sept. 7, 1867
300	LONGBOTHAM, J., Norley Collieries, near Wigan	May 2, 1868
301	LONGRIDGE, J. A., 15, Great George Street, Westminster, London, S.W.	Aug. 21, 1852
302	LUPTON, A., F.G.S., 4, Albion Place, Leeds	Nov. 6, 1869
303	MADDISON, HENRY, The Lindens, Darlington	Nov. 6, 1875
304	MALING, C. T., Ford Pottery, Newcastle-on-Tyne	Oct. 5, 1872
305	MAMMATT, J. E., C.E., St. Andrew's Chambers, Leeds	1864
306	MARLEY, JOHN, Thornfield, Darlington (VICE-PRESIDENT)	Aug. 21, 1852
307	MARLEY, J. W.	Aug. 1, 1868
308	MARSHALL, F. C., Messrs. R. & W. Hawthorn, Newcastle-on-Tyne ...	Aug. 2, 1866
309	MARSTON, W. B., Leeswood Vale Oil Works, Mold	Oct. 3, 1868
310	MARTEN, E. B., C.E., Pedmore, near Stourbridge	July 2, 1872
311	MATTHEWS, R. F., Ridley Hall, Bardon Mill, Carlisle	Mar. 5, 1857
312	MAUGHAN, J. A., Nerbudda Coal and Iron Co. Limited, Garrawarra, Central Provinces, India	Nov. 7, 1863
313	MAY, GEORGE, Harton Colliery Offices, near South Shields *(Member of Council)*	Mar. 6, 1862
314	MCCREATH, J., 95, Bath Street, Glasgow	Mar. 5, 1870
315	MCCULLOCH, DAVID, Beech Grove, Kilmarnock, N.B.	Dec. 4, 1875
316	MCCULLOCH, H. J., 4, Finsbury Circus, London	Oct. 1, 1863
317	MCCULLOCH, W., 4, Finsbury Circus, London	Nov. 7, 1874
318	MCGHIE, T., Cannock, Staffordshire	Oct. 1, 1857
319	MCMURTRIE, J., Radstock Colliery, Bath	Nov. 7, 1863
320	MEIK, THOMAS, C.E., 6, York Place, Edinburgh	June 4, 1870
321	MERIVALE, J. H., 2, Victoria Villas, Newcastle-on-Tyne	May 5, 1877
322	MILLER, ROBERT, Beech Grove, Lock Park, Barnsley	Mar. 2, 1865
323	MILLS, M. H., Duckmanton Lodge, Chesterfield	Feb. 4, 1871
324	MITCHELL, CHAS., Jesmond, Newcastle-on-Tyne	April 11, 1874
325	MITCHELL, JOSEPH, Bolton Hall, Rotherham	Feb, 14, 1874
326	MITCHINSON, R., Jun., Pontop Coll., Lintz Green Station, Co. Durham	Feb. 4, 1865
327	MOFFAT, T., Montreal Iron Ore Works, Whitehaven	Sept. 4, 1869
328	MONKHOUSE, JOS., Gilcrux, Cockermouth	June 4, 1863
329	MOOR, T., Cambois Colliery, Blyth	Oct. 3, 1868
330	MOOR, WM., Jun., Hetton Colliery, Fence Houses	July 2, 1872
331	MOORE, R. W., Colliery Office, Whitehaven	Nov. 5, 1870
332	MORISON, D. P.	1861
333	MORRIS, W., Waldridge Colliery, Chester-le-Street	1858
334*	MORTON H. J., 2, Westbourne Villas, South Cliff, Scarborough ...	Dec. 5, 1856

		ELECTED.
335	MORTON, H. T., Lambton, Fence Houses	Aug. 21, 1852
336	MOSES, WM., Silksworth Colliery, Sunderland	Mar. 2, 1872
337	MUCKLE, JOHN, 11, Oxford Terrace, Gateshead-on-Tyne	Mar. 7, 1861
338	MULVANY, W. T., Pêmpêlfort, Dusseldorf-on-the-Rhine	Dec. 3, 1857
339	MUNDLE, ARTHUR, 7, Collingwood Street, Newcastle-on-Tyne ...	June 5, 1875
340	MUNDLE, W., Redesdale Mines, Bellingham	Aug. 2, 1873
341*	NASSE, RUDOLPH, Konigl Bergwerks Director, Louisenthal, Saarbrücken, Prussia	1869
342	NEVIN, JOHN, Mirfield, Yorkshire	May 2, 1868
343	NEWALL, R. S., Ferndene, Gateshead-on-Tyne *(Member of Council)*...	May 2, 1863
344	NICHOLSON, E., jun., Beamish Colliery, Chester-le-Street	Aug. 7, 1869
345	NICHOLSON, MARSHALL, Middleton Hall, Leeds	Nov. 7, 1863
346	NOBLE, CAPTAIN, Jesmond, Newcastle-on-Tyne	Feb. 3, 1866
347	NORTH, F. W., F.G.S., Rowley Hall Colliery, Dudley, Staffordshire...	Oct. 6, 1864
348	OGDEN, JOHN M., Solicitor, Sunniside, Sunderland	Mar. 5, 1857
349	OGILVIE, A. GRAEME, 4, Great George Street, Westminster, London	Mar. 3, 1877
350	OLIVER, ROBERT, Charlaw Colliery, near Durham	Nov. 6, 1875
351	PACEY, T., Bishop Auckland	April 10, 1869
352	PALMER, A. S., Usworth Hall, Washington Station, Co. Durham ...	July 2, 1872
353	PALMER, C. M., M.P., Quay, Newcastle-on-Tyne	Nov. 5, 1852
354	PAMELY, C., Radstock Coal Works, near Bath	Sept. 5, 1868
355	PANTON, F. S., Silksworth Colliery, Sunderland	Oct. 5, 1867
356	PARKIN, C., Hutton-le-Hole, Kirby Moorside, York.	June 5, 1875
357	PARRINGTON, M. W., Wearmouth Colliery, Sunderland	Dec. 1, 1864
358	PARTON, T., F.G.S., Ash Cottage, Birmingham Road, West Bromwich	Oct. 2, 1869
359	PATTISON, JOHN, Engineer, Naples	Nov. 7, 1874
360	PEACE, M. W,, Wigan, Lancashire	July 2, 1872
361	PEACOCK, DAVID, West Bromwich	Aug. 7, 1869
362	PEARCE, F. H., Bowling Iron Works, Bradford	Oct. 1, 1857
363	PEASE, Sir J. W., Bart., M.P., Hutton Hall, Guisbro', Yorkshire ...	Mar. 5, 1857
364	PEEL, JOHN, Wharncliffe Silkstone Collieries, near Barnsley ...	Nov. 1, 1860
365	PEEL, JOHN, Horsley Colliery, Wylam-on-Tyne	Mar. 3, 1877
366	PEILE, WILLIAM, Ellerkeld, Stainburn, Workington	Oct. 1, 1863
367	PENMAN, J. H., 2, Clarence Buildings, Booth Street, Manchester ...	Mar. 7, 1874
368	PICKUP, P. W., Rishton, near Blackburn	Feb. 6, 1875
369	PINCHING, ARCHD. E., South Indian Mining Co., Glenrock Estate, Devala, Madras Residency, India	May 5, 1877
370	POTTER, ADDISON, C.B., Heaton Hall, Newcastle-on-Tyne	Mar. 6, 1869
371	POTTER, A. M., Shire Moor Coll., Northumberland *(Member of Council)*	Feb. 3, 1872
372	POTTER, C. J., Heaton Hall, Newcastle-on-Tyne	Oct. 3, 1874
373*	POTTER, W. A., Cramlington House, Northumberland	1853
374	PRICE, JOHN, Messrs. Palmer & Co., Limited, Jarrow-on-Tyne ...	Mar. 3, 1877
375	PRICE, J. R., Standish, near Wigan	Aug. 7, 1869
376	PRIESTMAN, JNO., Coal Owner, Newcastle-on-Tyne	Sept. 2, 1871
377	PRINGLE, EDWARD, Choppington Colliery, Northumberland	Aug. 4, 1877

		ELECTED.
378	RAMSAY, J. A., Thornley House, by Trimdon Grange. Co. Durham ...	Mar. 6, 1869
379	RAMSAY, WM., Tursdale Colliery, County Durham	Sept. 11, 1875
380	REED, ROBERT, Felling Colliery, Gateshead	Dec. 3, 1863
381	REES, DANIEL, Glandare, Aberdare	1862
382	REFKEN, WM., Teplitz, Bohemia	Oct. 5, 1872
383	REID, ANDREW, Newcastle-on-Tyne	April 2, 1870
384	RICHARDS, E. W., Messrs. Bolckow, Vaughan, & Co., Middlesbro' ...	Aug 5, 1876
385	RICHARDSON, H., Backworth Colliery, Newcastle-on-Tyne *(Member of Council)*	Mar. 2, 1865
386	RICHARDSON, J. W., Iron Shipbuilder, Newcastle-on-Tyne	Sept. 3, 1870
387	RIDLEY, G., Tyne Chambers, 38, Side, Newcastle-on-Tyne	Feb. 4, 1865
388	RIDLEY, J. H., Messrs. R. & W. Hawthorn, Newcastle-on-Tyne ...	April 6, 1872
389	RIDYARD, J., Bridgewater Offices, Walkden, nr. Bolton-le-Moors, Lan.	Nov. 7, 1874
390	RITSON, U. A., 6, Queen Street, Newcastle-on-Tyne	Oct. 7, 1871
391	RITSON, W. A., Tamworth Colliery Co., Tamworth	April 2, 1870
392	ROBERTSON, W., M.E., 123, St. Vincent Street, Glasgow	Mar. 5, 1870
393	ROBINSON, G. C., Brereton and Hayes Colls., Rugeley, Staffordshire...	Nov. 5, 1870
394	ROBINSON, JOHN	Nov. 4, 1876
395	ROBINSON, R., Howlish Hall, near Bishop Auckland *(Mem. of Council)*	Feb. 1, 1868
396	ROBSON, J. S., Butterknowle Colliery, *via* Darlington...	1853
397	ROBSON, J. T., Cambuslang, Glasgow	Sept. 4, 1869
398	ROBSON, THOMAS, Lumley Colliery, Fence Houses	Oct. 4, 1860
399	ROGERSON, John, Croxdale Hall, Durham	Mar. 6, 1869
400	ROSCAMP, J., West View, Morpeth	Feb. 2, 1867
401	ROSS, J. A. G., Consulting Engineer, 13, Belgrave Terrace, Newcastle	July 2, 1872
402	ROSSER, W., Mineral Surveyor, Llanelly, Carmarthenshire	1856
403	ROTHWELL, R. P., 27, Park Place, New York, U.S.	Mar. 5, 1870
404	ROUTLEDGE, Jos., Ryhope Colliery, Sunderland	Sept. 11, 1875
405	ROUTLEDGE, WM., S. and L.C. and R. Co., Reserve Colliery, Sydney, Cape Breton	Aug. 6, 1857
406	ROWLEY, J. C., Shagpoint Colliery, Otago, New Zealand	Dec. 4, 1875
407	RUTHERFORD, J., Halifax Coal Co., Ld., Albion Mines, Nova Scotia...	1852
408	RUTHERFORD, W., So. Derwent Colliery, Annfield Plain, Lintz Green	Oct. 3, 1874
409	RUTTER, THOS., Blaydon Main Colliery, Blaydon-on-Tyne	May 1, 1875
410	RYDER, W. J. H., Forth Street Brass Works, Newcastle-on-Tyne ...	Nov. 4, 1876
411	SAINT, GEORGE, Vauxhall Collieries, Ruabon, North Wales	April 11, 1874
412	SCARTH, W. T., Raby Castle, Darlington	April 4, 1868
413	SCOTT, ANDREW, Broomhill Colliery, Acklington	Dec. 7, 1867
414	SCOTT, C. F.	April 11, 1874
415	SCOULAR, G., Cleator Moor, *via* Carnforth	July 2, 1872
416	SHALLS, F. W., Pritchard & Sons, 9, Gracechurch Street, London ...	April 6, 1872
417	SHAW, W., Jun., Wolsingham, *via* Darlington...	June 3, 1871
418	SHIEL, JOHN, Framwellgate Colliery, County Durham	May 6, 1871
419	SHONE, ISAAC, Pentrefelin House, Wrexham	1858
420	SHORTREDE, T., Park House, Winstanley, Wigan	April 3, 1856
421	SHUTE, C. A., Westoe, South Shields	April 11, 1874
422	SIMPSON, J., Heworth Colliery, near Gateshead-on-Tyne	Dec. 6, 1866

		ELECTED.
423	SIMPSON, J. B., Hedgefield House, Blaydon-on-Tyne (VICE-PRESIDENT)	Oct. 4, 1860
424	SIMPSON, R., Moor House, Ryton-on-Tyne	Aug. 21, 1852
425	SIMPSON, ROBT., Drummond Coll., Westville, Pictou, Nova Scotia ...	Dec. 4, 1875
426	SLINN, T., 2, Choppington Street, Westmorland Road, Newcastle ...	July 2, 1872
427	SMALL, G., Duffield Road, Derby	June 4, 1870
428	SMITH, G. F., Grovehurst, Tunbridge Wells	Aug. 5, 1853
429	SMITH, J., Bickershaw Colliery, Leigh, near Manchester	Mar. 7, 1874
430*	SMITH, R. CLIFFORD, Parkfield, Swinton, Manchester	Dec. 5, 1874
431	SMITH, T., Sen., M.E., Cinderford Villas, nr. Newnham, Gloucester...	May, 5, 1877
432	SMITH, T. E., Phœnix Foundry, Newgate Street, Newcastle-on-Tyne	Dec. 5, 1874
433	SNOWDON, T., jun., West Bitchburn Coll., nr. Tow Law, *via* Darlington	Sept, 4, 1869
434	SOPWITH, A., Cannock Chase Collieries, near Walsall	Aug. 1, 1868
435	SOPWITH, THOS., 6, Great George St., Westminster, London, S.W. ...	Mar. 3, 1877
436	SOUTHERN, R., Burleigh House, The Parade, Tredegarville, Cardiff ...	Aug. 3, 1865
437	SOUTHWORTH, THOS., Hindley Green Collieries, near Wigan	May 2, 1874
438	SPENCER, JOHN, Westgate Road, Newcastle-on-Tyne	Sept. 4, 1869
439	SPENCER, M., Newburn, near Newcastle-on-Tyne	Sept. 4, 1869
440	SPENCER, T., Ryton, Newcastle-on-Tyne	Dec. 6, 1866
441	SPENCER, W., Southfields, Leicester	Aug. 21, 1852
442	STEAVENSON, A. L., Durham ... ... (VICE-PRESIDENT)	Dec. 6, 1855
443	STEPHENSON, G. R., 9, Victoria Chambers, Westminster, London, S.W.	Oct. 4, 1860
444	STEVENSON, R., Janefield Place, Lylesland, Paisley, N.B.	Feb. 5, 1876
445	STOBART, W., Pepper Arden, Northallerton	July 2, 1872
446	STOREY, THOS. E., Clough Hall Iron Works, Kidsgrove, Staffordshire	Feb. 5, 1876
447	STRAKER, JOHN, Stagshaw House, Corbridge-on-Tyne	May 2, 1867
448	STRAKER, J. H., Willington House, Co. Durham	Oct. 3, 1874
449	STRATTON, T. H. M., Tredegar, South Wales	Dec. 3, 1870
450	SWALLOW, J., Bushblades House, Lintz Green, Newcastle-on-Tyne ...	May 2, 1874
451	SWALLOW, R. T., Springwell, Gateshead-on-Tyne	1862
452	SWAN, H. F., Shipbuilder, Newcastle-on-Tyne	Sept. 2, 1871
453	SWAN, J. G., Upsall Hall, near Middlesbro'	Sept. 2, 1871
454	SWANN, C. G., Sec., General Mining Asso. Ld., 6, New Broad St., London	Aug. 7, 1875
455	TATE, SIMON, Trimdon Grange Colliery, Co. Durham	Sept. 11, 1875
456	TAYLOR, HUGH, King Street, Quay, Newcastle-on-Tyne	Sept. 5, 1856
457	TAYLOR, T., King Street, Quay, Newcastle-on-Tyne	July 2, 1872
458	TAYLOR-SMITH, THOMAS, Greencroft Park, Durham	Aug. 2, 1866
459	THOMAS, A., Bilson House, near Newnham, Gloucestershire	Mar. 2, 1872
460	THOMPSON, JOHN, Boughton Hall, Chester	Sept. 2, 1865
461	THOMPSON, R., Jun., Rodridge House, Wingate, Co. Durham ...	Sept. 7, 1867
462	THOMPSON, T. C., Milton Hall, Carlisle	May 4, 1854
463	THOMSON, JOHN, Eston Mines, by Middlesbro'	April 7, 1877
464	THOMSON, JOS. F., Manvers Main Colliery, Rotherham	Feb. 6, 1875
465	TINN, J., C.E., Ashton Iron Rolling Mills, Bower Ashton, Bristol ...	Sept. 7, 1867
466	TYLDEN-WRIGHT, C., Shireoaks Colliery, Worksop, Notts.	1862
467	TYSON, WM. JOHN, 15, Foxhouses Road, Whitehaven	Mar. 3, 1877
468	TYZACK, D.	Feb. 14, 1874
469	TYZACK, WILFRED, So. Medomsley Coll., Lintz Green, Newcastle ...	Oct. 7, 1876

		ELECTED.
470	VIVIAN, JOHN, Diamond Boring Company, Whitehaven	Mar. 3, 1877
471	WADHAM, E., C. and M.E., Millwood, Dalton-in-Furness	Dec. 7, 1867
472	WALKER, G. B., Wharncliffe Silkstone Collieries, Wortley, nr. Sheffield	Dec. 2, 1871
473	WALKER, J. S., 15, Wallgate, Wigan, Lancashire	Dec. 4, 1869
474	WALKER, W., Saltburn-by-the-Sea	Mar. 5, 1870
475	WALLACE, HENRY, Trench Hall, Gateshead	Nov. 2, 1872
476	WARD, H., Rodbaston Hall, near Penkridge, Stafford...	Mar. 6, 1862
477	WARDALE, JOHN D., Redheugh Engine Works, Gateshead	May 1, 1875
478	WARDELL, S. C., Doe Hill House, Alfreton	April 1, 1865
479	WARRINGTON, J., Cragwood, Rawdon, near Leeds	Oct. 6, 1859
480	WATSON, H., High Bridge Works, Newcastle-on-Tyne	Mar. 7, 1868
481	WATSON, H. B., High Bridge Works, Newcastle-on-Tyne	Mar. 3, 1877
482	WATSON, M., Dearham Main Collieries, near Maryport	Mar. 7, 1868
483	WEEKS, J. G., Bedlington Collieries, Bedlington *(Member of Council)*	Feb. 4, 1865
484	WESTMACOTT, P. G. B., Elswick Iron Works, Newcastle	June 2, 1866
485	WHITE, H., Weardale Coal Company, Tow Law, near Darlington ...	1866
486	WHITE, J. F., M.E., Wakefield	July 2, 1872
487	WHITE, J. W. H., Woodlesford, near Leeds	Sept. 2, 1876
488	WHITEHEAD, JAMES, Brindle Lodge, near Preston, Lancashire ...	Dec. 4, 1875
489	WHITELAW, JOHN, 118, George Street, Edinburgh	Feb. 5, 1870
490	WHITELAW, T., Shields and Dalzell Collieries, Motherwell	April 6, 1872
491	WHITTEM, THOS. S., Wyken Colliery, near Coventry	Dec. 5, 1874
492	WIDDAS, C., North Bitchburn Colliery, Howden, Darlington... ...	Dec. 5, 1868
493	WIGHT, W. H., Cowpen Colliery, Blyth...	Feb. 3, 1877
494	WILD, J. G., Hedley Hope Collieries, Tow Law, by Darlington ...	Oct. 5, 1867
495	WILLIAMS, E., Cleveland Lodge, Middlesbro'	Sept. 2, 1865
496	WILLIAMS, J. J., Pantgwyn House, Holywell, Flintshire	Nov. 2, 1872
497	WILLIAMSON, JOHN, Cannock, &c., Collieries, Hednesford	Nov. 2, 1872
498	WILLIS, J., 14, Portland Terrace, Newcastle *(Member of Council)* ...	Mar. 5, 1857
499	WILSON, J. B., Wingfield Iron Works and Colliery, Alfreton... ...	Nov. 5, 1852
500	WILSON, ROBERT, Flimby Colliery, Maryport	Aug. 1, 1874
501	WILSON, W. B., Kippax and Allerton Collieries, Leeds	Feb. 6, 1869
502	WINTER, T. B., Grey Street, Newcastle-on-Tyne	Oct. 7, 1871
503	WOOD, C. L., Freeland, Bridge of Earn, Perthshire	1853
504	WOOD, LINDSAY, Southill, Chester-le-Street (PAST PRESIDENT, *Member of Council)*	Oct. 1, 1857
505	WOOD, THOMAS, Rainton House, Fence Houses	Sept. 3, 1870
506	WOOD, W. H., Coxhoe Hall, Coxhoe, Co. Durham	1856
507	WOOD, W. O., Durham	Nov. 7, 1863
508	WOOLCOCK, HENRY, St. Bees, Cumberland	Mar. 3, 1873
509	WRIGHT, G. H.	July 2, 1872
510	WRIGHTSON, T., Stockton-on-Tees	Sept. 13, 1873
511	YOUNG, PHILIP	Oct. 11, 1873

Ordinary Members.

Marked * is a Life Member.

		ELECTED.
1	ACKROYD, WM., Jun., Morley Main Collieries, Morley, nr. Leeds ...	Feb. 7, 1880
2	BELL, C. E., Park House, Durham	Dec. 3, 1870
3	BROJA, RICHARD, Oberbergrath, Ostwall, Dortmund...	Nov. 6, 1880
4	BUTLER, W. F., C.E., Cymman Hall, near Wrexham	Feb. 7, 1880
5	CHARLTON, HENRY, Hawks, Crawshay, & Sons, Gateshead-on-Tyne	Dec. 9, 1882
6	COCHRANE, JOHN E., The North-West Provinces and Oude Ice Co., Limited, Lucknow Factory, India	Dec. 9, 1882
7	CROSS, W. A., Messrs. R. and W. Hawthorn, Newcastle-on-Tyne ...	April 12, 1884
8	DACRES, THOMAS, Silksworth Colliery, Sunderland	May 4, 1878
9	DEES, J. G., Floraville, Whitehaven	Oct. 13, 1883
10*	DIXON, JAMES S., 170, Hope Street, Glasgow	Aug. 3, 1878
11	ELLIS, W. R., F.G.S., Wigan	June 1, 1878
12	FORREST, B. J., Presser and Cia, Salesas 4, Madrid	April 12, 1884
13	FORREST, J. C., Witley Coal Co., Limited, Halesowen, Birmingham...	April 12, 1884
14	GEDDES, GEORGE H., 142 Princes Street, Edinburgh	Oct. 1, 1881
15	GILCHRIST, THOMAS, Eltringham, Prudhoe-on-Tyne	May 4, 1878
16	GOUDIE, J. H., 13, Lowther Street, Whitehaven	Sept. 7, 1878
17	HARBOTTLE, JOHN, Linlithgow Mines, Columbia Co., New York ...	June 10, 1882
18	JAMESON, JOHN, Akenside Hill, Newcastle-on-Tyne	April 12, 1884
19	JOHNSON, HENRY, Jun., Sandwell Park Colliery, West Bromwich, South Staffordshire	Feb. 10, 1883
20	JOHNSON, WILLIAM, West Stanley Colliery, Chester-le-Street ...	Dec. 9, 1882
21	KELLETT, WILLIAM, Wigan	June 1, 1878
22	KNOWLES, I., Wigan	Oct. 13, 1883
23	LANCASTER, JOHN, Auchinbeath, Southfield and Fence Collieries, Lesmahagow	Sept. 7, 1878
24	LAWS, W. G., Town Hall, Newcastle-on-Tyne *(Member of Council)*...	Oct. 2, 1880
25	LEACH, C. C., Bedlington Colls., Bedlington, R.S.O., Northumberland	Mar. 7, 1874
26	LIDDELL, MATTHEW, Mickley Colliery Offices, Stocksfield-on-Tyne ...	Feb. 10, 1883
27	LLEWELLIN, DAVID MORGAN, F.G.S., Glanwern Offices, Pontypool ...	May 14, 1881
28	MARTIN, TOM PATTINSON, Allhallows Colliery, Mealsgate, Carlisle ...	Feb. 15, 1879
29	OLDHAM, G. H., St. John D'El Rey Mining Co., Tower Chambers, Finsbury Pavement, London	Aug. 5, 1882
30	POTTS, JOS., Jun., North Cliff, Roker, Sunderland	Dec. 6, 1879
31	PRIOR, EDWARD G., Victoria, British Columbia...	Feb. 7, 1880
32	RHODES, C. E., Carr House, Rotherham	Aug. 4, 1883
33	ROGERS, WILLIAM, 19, King Street, Wigan	Nov. 2, 1878
34	RUSSELL, ROBERT, Coltness Iron Works, Newmains, N.B.	Aug. 3, 1878
35	SELBY, ATHERTON, Leigh, near Manchester	Oct. 13, 1883
36	SPENCER, JOHN W., Newburn, near Newcastle-on-Tyne	May 4, 1878
37	TOPPING, WALTER, Messrs. Cross, Tetley, & Co., Platt Bridge, Wigan	Mar. 2, 1878
38	WALKER, SIDNEY FERRIS, 195, Severn Road, Canton, Cardiff ...	Dec. 9, 1882
39	WALKER, WILLIAM EDWARD, Lowther Street, Whitehaven	Nov. 19, 1881
40	WINSTANLEY, ROBT., M.E., 28, Deansgate, Manchester	Sept. 7, 1878

Associate Members.

Marked * are Life Members.

		ELECTED.
1	ADAMSON, L. W., Whitley House, Whitley, Northumberland ...	Feb. 9, 1884
2	ALLAN, JOHN, 607 Erbische Strasse, Freiberg in Sachsen	Feb. 10, 1883
3	ARMSTRONG, HENRY, St. Hilda Colliery, South Shields	April 14, 1883
4	ARMSTRONG, T. J., Hawthorn Terrace, Newcastle-on-Tyne	Feb. 10, 1883
5	ARNOLD, THOS., Mineral Surveyor, Castle Hill, Greenfields, Llanelly	Oct. 2, 1880
6	ATKINSON, FRED., Maryport	Feb. 14, 1874
7	AUDUS, T., Mineral Traffic Manager, N.E. Railway, Newcastle-on-Tyne	Aug. 7, 1880
8	AYTON, E. F., Heddon Colliery, Wylam-on-Tyne	Feb. 5, 1876
9	AYTON, HENRY, Seaton Delaval Colliery, Dudley, Northumberland ...	Mar. 6, 1875
10	BAILES, E. T., Wingate, Ferryhill	June 7, 1879
11	BARNES, A. W., Grassmore Colliery, near Chesterfield	Oct. 5, 1872
12	BARRETT, C. R., New Seaham, Sunderland	Nov. 7, 1874
13	BATES, C. J., Heddon Banks, near Wylam-on-Tyne	Dec. 11, 1882
14*	BELL, THOMAS HUGH, Middlesbrough-on-Tees...	Dec. 11, 1882
15	BERKLEY, FREDERICK, Murton Colliery, near Sunderland	Dec. 11, 1882
16	BERKLEY, R. W., Marley Hill Colliery, Gateshead	Feb. 14, 1874
17	BEWICK, T. B., Haydon Bridge, Northumberland	Mar. 7, 1874
18	BIRD, W. J., 9, Prince Street, Sunderland	Nov. 6, 1875
19	BOUCHER, A. S., La Salada puerto Bertio, E de Antioguia, United States of Colombia, S.A.	Aug. 4, 1883
20	BOWES, JOHN, Streatlam Castle, Darlington	Feb. 10, 1883
21	BROUGH, THOMAS, Seaham Colliery; Seaham Harbour	Feb. 1, 1873
22	BROWN, M. W., 7, Elswick Park, Newcastle-on-Tyne	Oct. 7, 1871
23	BROWN, W. B., 101, Leadenhall Street, London, E.C.	Mar. 2, 1878
24	BRUCE, JOHN, Cannock Chase Colliery, near Walsall	Feb. 14, 1874
25	BULMAN, H. F., West Rainton, Fence Houses	May 2, 1874
26	BUNNING, C. Z., Warora Colliery, Central Provinces, India	Dec. 6, 1873
27	BURDON, A. E., Hartford House, Cramlington, Northumberland ...	Feb. 10, 1883
28	BURNLEY, C. E., Aybrigg Farm, near Wakefield	April 11, 1874
29	CABRERA, FIDEL, c/o H. Kendall & Son, 12, Gt. Winchester St., London	Oct. 6, 1877
30	CANDLER, T. E., Canton Club, Canton, China	May 1, 1875
31	CHARLTON, W. A., Tangye Bros., 25, Lincoln St., Gateshead-on-Tyne	Nov. 6, 1880
32	CLOUGH, JAMES, Bedlington Collieries, R.S.O., Northumberland ...	April 5, 1873
33	COBBOLD, C. H.	May 3, 1873
34	COCHRANE, RALPH D., Hetton Colliery Offices, Fence Houses ...	June 1, 1878
35	COCKSON, CHARLES, King Street, Wigan	April 22, 1882
36	COOPER, R. W., Solicitor, Newcastle-on-Tyne	Sept. 4, 1880
37	CRAWFORD, T. W., Tees Hetton Coal Co., Limited, Evenwood, Bishop Auckland	Dec. 4, 1875
38	DAKERS, W. R., Croxdale Colliery, Durham	Oct. 14, 1882
39	DALZIEL, W. G., 2, Pembroke Terrace, Cardiff	Sept. 7, 1878
40	DAVISON, CHARLES, Cornsay Colliery, near Esh, Durham	Dec. 11, 1882

		ELECTED
41	DODD, M., Lemington, Scotswood-on-Tyne	Dec. 4, 1875
42	DOUGLAS, JOHN, Seghill Colliery, Dudley, Northumberland	April 22, 1882
43	DOUGLAS, JOHN, Jun., Seghill Colliery, Dudley, Northumberland ...	April 22, 1882
44	DOUGLAS, M. H., Marsden Colliery, South Shields	Aug. 2, 1879
45	DOYLE, PATRICK	Mar. 1, 1879
46	EDGE, J. C., Eckington Colliery, near Chesterfield	Dec. 5, 1874
47	EDGE, JOHN H., Coalport Wire Rope and Chain Works, Shifnal, Salop	Sept. 7, 1878
48	FAIRLEY, JAMES, Craghead and Holmside Collieries, Chester-le-Street	Aug. 7, 1880
49	FARROW, JOSEPH, Brotton Mines, Brotton, R.S.O.	Feb. 11, 1882
50	FERGUSON, D., 124, New City Road, Glasgow	Dec. 8, 1883
51	FLETCHER, W., Brigham Hill, *via* Carlisle	Oct. 13, 1883
52	FRYAR, MARK, Denby Colliery, Derby	Oct. 7, 1876
53	GERRARD, JAMES, 19, King Street, Wigan	Mar. 3, 1873
54	GREENER, HENRY, South Pontop Colliery, Annfield Plain	Dec. 11, 1882
55	GREENER, T. Y., Rainford Collieries, St. Helen's, Lancashire... ...	July 2, 1872
56	GREENER, W. J., Pemberton Colliery, Wigan	Mar. 2, 1878
57	GRESLEY, W. S., Overseale, Ashby-de-la-Zouch	Oct. 5, 1878
58	GUTHRIE, J. K., St. Thomas' Terrace, Blaydon-on-Tyne	Mar. 1, 1879
59	HAGGIE, PETER SINCLAIR, Gateshead-on-Tyne	April 14, 1883
60	HALLAS, G. H., Hindley Green Colliery, near Wigan	Oct. 7, 1876
61	HAMILTON, E., Rig Wood, Saltburn-by-the-Sea	Nov. 1, 1873
62	HARRIS, W. S., Andrews House, near Gateshead-on-Tyne	Feb. 14, 1874
63	HEDLEY, E., Rainham Lodge, The Avenue, Beckenham, Kent ...	Dec. 2, 1871
64	HENDERSON, C. W. C., The Riding, Hexham	Dec. 11, 1882
65	HENRY, GEO. J., Stowmarket Gun Cotton Co., Stowmarket	Nov. 19, 1881
66	HILL, WILLIAM, Carterthorne Colliery Offices, Witton-le-Wear ...	June 9, 1883
67	HUMBLE, STEPHEN, 5, Westminster Chambers, Victoria St., London, S.W.	Oct. 6, 1877
68	JEFFCOCK, CHARLES E., Birley Collieries, Sheffield	Feb. 10, 1883
69	JEPSON, H., 54, Old Elvet, Durham	July 2, 1872
70*	JOBLING, THOS. E., Bebside Colliery, Cowpen Lane, Northumberland	Oct. 7, 1876
71	JOHNSON, F. D., Aykleyheads, Durham	Feb. 10, 1883
72	JOHNSON, W., Abram Colliery, Wigan	Feb. 14, 1874
73	JORDAN, J. J.	Mar. 3, 1873
74	LAVERICK, JOHN WALES, Middridge Colliery, Shildon, *via* Darlington	Dec. 11, 1882
75	LIDDELL, J. M., 21, Lovaine Place, Newcastle-on-Tyne	Mar. 6, 1875
76	LIDDELL, JOHN, Coal Owner, Newcastle-on-Tyne	Dec. 11, 1882
77	LISLE, J., Washington Colliery, County Durham	July 2, 1872
78	LIVEING, E. H., 6, Westminster Chambers, Victoria St., London, S.W.	Sept. 1, 1877
79	MACCABE, H. O., Russell Vale, Wollongong, New South Wales ...	Sept. 7, 1878
80	MADDISON, THOS. R., Thornes, near Wakefield	Mar. 3, 1877
81	MAKEPEACE, H. R., Bellshill, N.B.	Mar. 3, 1877
82	MARKHAM, G. E., Howlish Offices, Bishop Auckland	Dec. 4, 1875
83	MELLY, E. F., Griff Collieries, Nuneaton	Oct. 5, 1878

		ELECTED.
84*	MERIVALE, W., c/o Mackinnon and Mackenzie, Bombay	Mar. 5, 1881
85	MILLER, D. S., Neston Collieries, Cheshire	Nov. 7, 1874
86*	MILLER, N....	Oct. 5, 1878
87	MONKHOUSE, G. BENSON, St. Nicholas' Chambers, Newcastle-on-Tyne	Oct. 14, 1882
88	MOORE, WILLIAM, Upleatham Mines, Upleatham, R.S.O.	Nov. 19, 1881
89	MOREING, C. A., 34, Clement's Lane, London, E.C.	Nov. 7, 1874
90	MORISON, JOHN, Newbattle Collieries, Dalkeith, N.B.	Dec. 4, 1880
91	ORNSBY, R. E., Seaton Delaval Colliery, Dudley, Northumberland ..	Mar. 6, 1875
92	PALMER, HENRY, East Howle Colliery, near Ferryhill	Nov. 2, 1878
93	PEAKE, C. E., Sleaford, Lincolnshire	Nov. 3, 1877
94*	PEASE, ARTHUR, M.P., Darlington	Dec. 11, 1882
95	PHILLIPS, W. J., Ansley Hall Colliery, Atherstone	June 9, 1883
96	PREST, J. J., St. Helen's Colliery, Bishop Auckland	May 1, 1875
97	PREST, T., Peases West Collieries, Crook, by Darlington	June 14, 1884
98	PRICHARD, W., Nav. and Deep Duffryn Colls., Mountain Ash, So. Wales	Dec. 7, 1878
99	PRINGLE, JOS., Manager, Coxlodge Colliery, So. Gosforth, Newcastle	Mar. 5, 1881
100	PROUD, JOSEPH, South Hetton Colliery Offices, Sunderland	Oct. 14, 1882
101	RATHBONE, EDGAR P., 2, Great George Street, Westminster, London	Mar. 7, 1874
102	RIDLEY, Sir MATTHEW WHITE, Bart., M.P., Blagdon, Northumberland	Feb. 10, 1883
103	ROBSON, HARRY N., 3, North Bailey, Durham...	Dec. 4, 1875
104	ROBSON, T. O., Redheugh Colliery, Gateshead-on-Tyne	Sept. 11, 1875
105	ROWELL, ROBERT, Seghill Colliery Office, Newcastle-on-Tyne ...	Feb. 10, 1883
106	SAISE, W., Manager E.I.R. Collieries, Giridi, Bengal, India	Nov. 3, 1877
107	SAWYER, A. R., Ass. R.S.M., Basford, Stoke-upon-Trent	Dec. 6, 1873
108	SCURFIELD, GEO. J., Hurworth-upon-Tees, Darlington	Dec. 11, 1882
109	SMITH, J. BAGNOLD, Langwith Colliery, near Mansfield	Nov. 2, 1878
110	SMITH, THOS. READER, M.E., Thorncliffe Collieries, near Sheffield ...	Feb. 5, 1881
111	SNOWBALL, JOSEPH, Seaton Burn House, Northumberland	Feb. 10, 1883
112	STILL, F. M., 3, Queen Street, Cheapside, London	Dec. 8, 1883
113	SPENCE, R. F., Cramlington	Nov. 2, 1878
114	STOBART, F., Pensher House, Fence Houses	Aug. 2. 1873
115	STOBBS, FRANK, 1, Queen Street, Newcastle-on-Tyne	Oct. 1, 1881
116	STONES, T. H., Wigan Coal & Iron Co., Westleigh, nr. Leigh, Lancashire	Nov. 7, 1874
117	TELFORD, W. H., Cramlington Colliery, Northumberland	Oct. 3, 1874
118	THOMAS, WILLIAM, M.E., Mineral Office, The Castle, Cockermouth...	Feb. 10, 1883
119	THOMPSON, CHARLES LACY, Milton Hall, Carlisle	Feb. 10, 1883
120	TURNBULL, GEORGE, Seaham Colliery, Seaham Harbour	Oct. 4, 1879
121	TYZACK, B. C., Preston Road, North Shields	Dec. 8, 1883
122	VITANOFF, GEO. N., Sofia, Bulgaria	April 22, 1882
123	WALLAU, JACOB, Messrs. Black, Hawthorn and Co., Gateshead ...	Feb. 9, 1884
124	WALTERS, HARGRAVE, Birley Collieries, near Sheffield	June 4, 1881
125	WALTON, J. COULTHARD, Writhlington Collieries, Radstock, *via* Bath	Nov. 7, 1874

		ELECTED.
126*	WARD, T. H., Assistant Manager, E.I.R. Collieries, Giridi, Bengal, India	Aug. 7, 1882
127	WARDLE, EDWARD, Craghead Colliery, Chester-le-Street	Feb. 5, 1881
128	WATSON, ROBERT, North Seaton, Morpeth	Dec. 11, 1882
129	WEBSTER, H. INGHAM, Morton House, Fence Houses	April 14, 1883
130	WEEKS, R. L., Willington, Co. Durham	June 10, 1882
131	WILSON, JOHN R., Swaithe, near Barnsley	June 9, 1883
132	WORMALD, C. F., Cross House, Corbridge	Dec. 8, 1883

Students.

1	ANDERSON, R. S., Elswick Colliery, Newcastle-on-Tyne	June 9, 1883
2	ATKINSON, A. A., Lumley Colliery, Fence Houses	Aug. 3, 1878
3	BARRASS, M., Tudhoe Colliery, Spennymoor	Dec. 10, 1883
4	BAUMGARTNER, W. O., Trimdon Grange Coll., Co. Durham	Sept. 6, 1879
5	BELL, GEO. FRED., 25, Old Elvet, Durham	Sept. 6, 1879
6	BIRD, HARRY, Fawler Iron Mines, Charlbury	April 7, 1877
7	BLACKETT, W. C., Jun., Kimblesworth Colliery, Chester-le-Street ...	Nov. 4, 1876
8	BLAKELEY, A. B., Hollyroyd, Dewsbury	Feb. 15, 1879
9	BRAMWELL, HUGH, 20, Beverley Terrace, Cullercoats	Oct. 4, 1879
10	BROWN, C. GILPIN, Hetton Colliery, Fence Houses	Nov. 4, 1876
11	CHANDLEY, CHARLES, Atherton Collieries, near Manchester	Nov. 6, 1880
12	CHAPMAN, ALF. C., Silksworth Hall, near Sunderland	Oct. 4, 1879
13	CHILD, H.	Feb. 15, 1879
14	COLE, COLLIN, Simonside Cottage, Tyne Dock, South Shields ...	Oct. 18, 1882
15	CRAWFORD, JAMES MILL, Murton Colliery, near Sunderland ...	Dec. 11, 1882
16	CRONE, F. E., Killingworth House, near Newcastle-on-Tyne	Sept. 2, 1876
17	CURRY, W. THOS., Usworth Colliery, *via* Washington, R.S.O. ...	Sept. 4, 1880
18	DAVIDSON, C. C., Ore Bank House, Bigrigg, *via* Carnforth, Cumberland	Nov. 4, 1876
19	DAVIS, KENNETH M., Towneley and Stella Collieries, Ryton-on-Tyne	April 5, 1879
20	DEPLEDGE, M. F.	April 7, 1877
21	DONKIN, WM., Mohain Mines, Gadawara, C.P., India	Sept. 2, 1876
22	DOUGLAS, A. S., Stanley Villa, near Crook, *via* Darlington	June 1, 1878
23	DUNN, A. F., Poynton, Stockport, Cheshire	June 2, 1877
24	DURNFORD, H. ST. JOHN, Low Stublin Colliery, near Rotherham ...	June 2, 1877
25	EVANS, DAVID L., Messrs. Dalziel & Evans, Cardiff	May 4, 1878
26	FERENS, FREDERICK J., 220, Gilesgate, Durham	Dec. 4, 1880
27	FORSTER, C. W., 6, Ellison Place, Newcastle-on-Tyne...	June 10, 1882
28	FORSTER, THOMAS E., Lesbury, R.S.O., Northumberland	Oct. 7, 1876
29	FOWLER, ROBERT, Wearmouth Colliery, Sunderland	Dec. 2, 1876
30	GALLWEY, ARTHUR P., El Callao Gold Mine, Guiana, Venezuela, S.A.	Oct. 2, 1880
31	GILCHRIST, J. R., Durham Main Colliery, Durham	Feb. 3, 1877
32	GORDON, CHAS., Glebe Street, Stoke-on-Trent	May 5, 1877

ELECTED.

33 GOULD, ALEX., 6, Ellison Place, Newcastle-on-Tyne ... ... Dec. 1, 1877
34 GREEN, FRANCIS W., Harton Colliery Offices, South Shields ... April 22, 1882
35 GREIG, J., Brancepeth Village, Co. Durham ... ... Feb. 5, 1881

36 HADDOCK, W. T., Jun., Ryhope Colliery, Sunderland ... ... Oct. 7, 1876
37 HAGGIE, DOUGLAS, Harton Colliery, South Shields ... ... April 14, 1883
38 HAIG, R. NOBLE ... ... Feb. 10, 1883
39 HARE, SAMUEL, Broughton and Plas Power Coal Co., Ltd., Wrexham Aug. 2, 1879
40 HARRISON, ROBERT J. ... ... May 1, 1875
41 HARRISON, R. W., Public Wharf, Leicester ... ... Mar. 3, 1877
42 HAY, W., Jun., Nostell Colliery, Wakefield ... ... Dec. 10, 1883
43 HEDLEY, SEPT. H., Wardley, Newcastle-on-Tyne ... ... Feb. 15, 1879
44 HENDY, J. C. B., Middle Bitchburn Colliery, Howden-le-Wear, *via* Darlington ... ... Sept. 2, 1876
45 HESLOP, SEPTIMUS, Urpeth, Chester-le-Street ... ... Dec. 4, 1880
46 HESLOP, THOMAS, Storey Lodge Colliery, Cockfield, *via* Darlington... Oct. 2, 1880
47 HILL, LEONARD, Newport Wire Mills, Middlesbro' ... . Oct. 6, 1877
48 HOOPER, EDWARD, Haydon Bridge, Northumberland... .. .. June 4, 1881
49 HOWARD, WALTER, 13, Cavendish Street, Chesterfield ... ... April 13, 1878
50 HUDSON, JOSEPH G. S., Albion Mines, Pictou County, Nova Scotia... Mar. 2, 1878
51 HUMBLE, JOICEY, 17, Westmorland Terrace, Newcastle-on-Tyne ... Mar. 3, 1877
52 HUMBLE, ROBERT, The Poplars, Ebchester, Co. Durham ... ... Sept. 2, 1876
53 HURST, GEO., Seaton Delaval Colliery, Northumberland ... ... April 14, 1883
54 HUTT, E. H., Usworth Coll., Washington Station R.S.O., Co. Durham Aug. 4, 1883

55 KAYLL, A. C., Felling Colliery, Gateshead-on-Tyne ... ... Oct. 7, 1876
56 KIRKHOUSE, E. G., Medomsley, Lintz Green, Newcastle-on-Tyne ... Aug. 3, 1878
57 KIRKUP, PHILIP, Esh Colliery, near Durham ... ... Mar. 2, 1878
58 KIRTON, HUGH, Waldridge Colliery, Chester-le-Street ... ... April 7, 1877

59 LINDSAY, C. S., Usworth, *via* Washington R.S.O. ... ... Mar. 4, 1876
60 LISHMAN, R. R., Celynen Colliery, Abercarne, *via* Newport, Mon. ... June 9, 1883
61 LOCKE, E. G. ... ... Dec. 2, 1876
62 LONGBOTHAM, R. H., Brynkinalt Colliery, Chirk, Wales ... ... Sept. 2, 1876

63 MACKINLAY, T. B., West Pelton Colliery, Chester-le-Street ... ... Nov. 1, 1879
64 MARSTON, FRANK, Bromfield Hall, Mold ... ... Aug. 7, 1882
65 MCLAREN, B., Bedlington R.S.O., Northumberland ... ... Dec. 10, 1883
66 MITTON, A. D., Sherburn House, Durham ... ... June 9, 1883
67 MURRAY, W. C., Weed Park, Dipton, *via* Lintz Green Station ... Oct. 4, 1879
68 MURTON, CHARLES J., Jesmond Villas, Newcastle-on-Tyne ... ... Mar. 6, 1880

69 NICHOLSON, J. C., Wear Steel and File Works, Sunderland ... ... Feb. 3, 1877
70 NICHOLSON, J. H., Cambois Colliery, Blyth, Northumberland ... Oct. 1, 1881
71 NOBLE, J. C., Usworth Hall, near Washington Station, Co. Durham... May 5, 1877

72 OATES, ROBERT J. W., E.I.R. Collieries, Giridi, Bengal, India ... Feb. 10, 1883

73 PATTISON, JOS. W., Londonderry Offices, Seaham Harbour ... ... Feb. 15, 1879
74 PEAKE, R. C., Highgate, Wallsall ... ... Feb. 7, 1880

		ELECTED.
75	PEART, A. W., Lower Duffryn Collieries, near Mountain Ash ...	Nov. 4, 1876
76	PEASE, J. T., Pierremont, Darlington	June 9, 1883
77	PIKE, ARNOLD, Kimblesworth Colliery, Chester-le-Street	Feb. 5, 1881
78	POTTER, E. A., Cramlington House, Northumberland	Feb. 6, 1875
79	PRICE, S. R., Houghton Main Colliery, near Barnsley, Yorkshire ...	Nov. 3, 1877
80	PRINGLE, H. A., Peases' West Collieries, Crook, by Darlington ...	Oct. 2, 1880
81	PRINGLE, HY. GEO., Tanfield Lea Coll., Lintz Green Station, Newcastle	Dec. 4, 1880
82	PROCTOR, C. P., Shibden Hall Collieries, near Halifax, Yorkshire ...	Oct. 7, 1876
83	REED, R., North Seaton Colliery, Morpeth	Feb. 3, 1877
84	RICHARDSON, RALPH, Field House, West Rainton, Fence Houses ...	June 9, 1883
85	RICHARDSON, R. W. P., Office of General Manager, Cedral Mining and Smelting Co.'s Mines, Villa de Musquiz Coalmila, Mexico ...	Mar. 4, 1876
86	RIDLEY, WILLIAM, South Tanfield Colliery, Chester-le-Street ...	Dec. 11, 1882
87	ROBINSON, FRANK, Norley Colliery, Wigan	Sept. 2, 1876
88	ROBINSON, GEO.	Nov. 4, 1876
89	ROUTLEDGE, W. H., Staveley Coal and Iron Co. Limited, Chesterfield	Oct. 7, 1876
90	SCARTH, R. W., Dishforth, near Thirsk...	Dec. 4, 1875
91	SCOTT, JOSEPH SAMUEL, East Hetton Colliery, Coxhoe, Co. Durham	Nov. 19, 1881
92	SCOTT, WALTER, Cornsay Colliery, Lanchester, Co. Durham... ...	Sept. 6, 1879
93	SCOTT, WM., Brancepeth Colliery Offices, Willington, Co. Durham ...	Mar. 4, 1876
94	SIMPSON, F. R., Hedgefield House, Blaydon-on-Tyne	Aug. 4, 1883
95	SMITH, THOS., Leadgate, Co. Durham	Feb. 15, 1879
96	SMITH, T. F., Jun., Cinderford Villas, near Newnham, Gloucestershire	May 5, 1877
97	SOUTHERN, E. O., Breeze Hill, Whitehaven	Dec. 5, 1874
98	SOUTHERN, THOMAS, Cwmaman Colliery, near Aberdare, South Wales	Dec. 17, 1881
99	STEAVENSON, C. H., Durham	April 14, 1883
100	STOBART, H. T., Washington Colliery, Washington Station R.S.O., Co. Durham	Oct. 2, 1880
101	STOKER, ARTHUR P., Birtley, near Chester-le-Street	Oct. 6, 1877
102	TODD, JOHN T., Hetton-le-Hole, Fence Houses...	Nov. 4, 1876
103	TODNER, W. J. S., 33, Beaumont Street, Elswick, Newcastle-on-Tyne	Sept. 6, 1879
104	WAUGH, CHARLES L., Ffalda Steam Coal Colliery, Garw Valley, near Bridgend	Nov. 19, 1881
105	WHITE, C. E., Hebburn Colliery, near Newcastle-on-Tyne	Nov. 4, 1876
106	WILSON, J. D., Ouston House, Chester-le-Street	Sept. 11, 1875

Subscribers under Bye-law 9.

1 Ashington Colliery, Newcastle-on-Tyne.
2 Birtley Iron Company, Birtley.
3 Haswell Colliery, Fence Houses.
4 Hetton Collieries, Fence Houses.
5 Lambton Collieries, Fence Houses.
6 Londonderry Collieries, Seaham Harbour.
7 Marquess of Bute.
8 North Hetton Colliery, Fence Houses.
9 Ryhope Colliery, near Sunderland.
10 Seghill Colliery, Northumberland.
11 South Hetton and Murton Collieries.
12 Stella Colliery, Hedgefield, Blaydon-on-Tyne.
13 Throckley Colliery, Newcastle-on-Tyne.
14 Victoria Garesfield, Lintz Green.
15 Wearmouth Colliery, Sunderland.

Summary of Members.

*Original Members	511
Ordinary Members	40
Associate Members	132
*Honorary Members	21
Students Class	106
Subscribers under Bye-law 9	15
	823

* Two Original are also Honorary Members

CHARTER

OF

THE NORTH OF ENGLAND

Institute of Mining and Mechanical Engineers.

FOUNDED 1852.

INCORPORATED NOVEMBER 28TH, 1876.

Victoria, by the Grace of God, of the United Kingdom of Great Britain and Ireland, Queen, Defender of the Faith, TO ALL TO WHOM THESE PRESENTS SHALL COME, GREETING:

WHEREAS it has been represented to us that NICHOLAS WOOD, of Hetton, in the County of Durham, Esquire (since deceased); THOMAS EMERSON FORSTER, of Newcastle-upon-Tyne, Esquire (since deceased); SIR GEORGE ELLIOT, Baronet (then George Elliot, Esquire), of Houghton Hall, in the said County of Durham, and EDWARD FENWICK BOYD, of Moor House, in the said County of Durham, Esquire, and others of our loving subjects, did, in the year one thousand eight hundred and fifty-two, form themselves into a Society, which is known by the name of THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, having for its objects the Prevention of Accidents in Mines and the Advancement of the Sciences of Mining and Engineering generally, of which Society LINDSAY WOOD, of Southill, Chester-le-Street, in the County of Durham, Esquire, is the present President. AND WHEREAS it has been further represented to us that the Society was not constituted for gain, and that neither its projectors nor Members derive nor have derived pecuniary profit from its prosperity; that it has during its existence of a period of nearly a quarter of a century steadily devoted itself to the preservation of human life and the safer development of mineral property; that it has contributed substantially and beneficially to the prosperity of the country and the welfare and happiness of the working members of the community; that the Society has since its establishment diligently pursued its aforesaid objects, and in so doing has made costly experiments

and researches with a view to the saving of life by improvements in the ventilation of mines, by ascertaining the conditions under which the safety lamp may be relied on for security; that the experiments conducted by the Society have related to accidents in mines of every description, and have not been limited to those proceeding from explosions; that the various modes of getting coal, whether by mechanical appliances or otherwise, have received careful and continuous attention, while the improvements in the mode of working and hauling belowground, the machinery employed for preventing the disastrous falls of roof underground, and the prevention of spontaneous combustion in seams of coal as well as in cargoes, and the providing additional security for the miners in ascending and descending the pits, the improvements in the cages used for this purpose, and in the safeguards against what is technically known as "overwinding," have been most successful in lessening the dangers of mining, and in preserving human life; that the Society has held meetings at stated periods, at which the results of the said experiments and researches have been considered and discussed, and has published a series of Transactions filling many volumes, and forming in itself a highly valuable Library of scientific reference, by which the same have been made known to the public, and has formed a Library of Scientific Works and Collections of Models and Apparatus, and that distinguished persons in foreign countries have availed themselves of the facilities afforded by the Society for communicating important scientific and practical discoveries, and thus a useful interchange of valuable information has been effected; that in particular, with regard to ventilation, the experiments and researches of the Society, which have involved much pecuniary outlay and personal labour, and the details of which are recorded in the successive volumes of the Society's Transactions, have led to large and important advances in the practical knowledge of that subject, and that the Society's researches have tended largely to increase the security of life; that the Members of the Society exceed 800 in number, and include a large proportion of the leading Mining Engineers in the United Kingdom. AND WHEREAS in order to secure the property of the Society, and to extend its useful operations, and to give it a more permanent establishment among the Scientific Institutions of our Kingdom, we have been besought to grant to the said LINDSAY WOOD, and other the present Members of the Society, and to those who shall hereafter become Members thereof, our Royal Charter of Incorporation. NOW KNOW YE that we, being desirous of encouraging a design so laudable and salutary of our special grace, certain knowledge, and mere motion, have willed granted, and declared, and

do, by these presents, for us, our heirs, and successors, will, grant, and declare, that the said LINDSAY WOOD, and such others of our loving subjects as are now Members of the said Society, and such others as shall from time to time hereafter become Members thereof, according to such Bye-laws as shall be made as hereinafter mentioned, and their successors, shall for ever hereafter be, by virtue of these presents, one body, politic and corporate, by the name of "THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS," and by the name aforesaid shall have perpetual succession and a Common Seal, with full power and authority to alter, vary, break, and renew the same at their discretion, and by the same name to sue and be sued, implead and be impleaded, answer and be answered unto, in every Court of us, our heirs and successors, and be for ever able and capable in the law to purchase, acquire, receive, possess, hold, and enjoy to them and their successors any goods and chattels whatsoever, and also be able and capable in the law (notwithstanding the statutes and mortmain) to purchase, acquire, possess, hold and enjoy to them and their successors a hall or house, and any such other lands, tenements, or hereditaments whatsoever, as they may deem requisite for the purposes of the Society, the yearly value of which, including the site of the said hall or house, shall not exceed in the whole the sum of three thousand pounds, computing the same respectfully at the rack rent which might have been had or gotten for the same respectfully at the time of the purchase or acquisition thereof. AND WE DO HEREBY GRANT our especial licence and authority unto all and every person and persons and bodies politic and corporate, otherwise competent, to grant, sell, alien, convey or devise in mortmain unto and to the use of the said Society and their successors, any lands, tenements, or hereditaments not exceeding with the lands, tenements or hereditaments so purchased or previously acquired such annual value as aforesaid, and also any moneys, stocks, securities, and other personal estate to be laid out and disposed of in the purchase of any lands, tenements, or hereditaments not exceeding the like annual value. AND WE FURTHER will, grant, and declare, that the said Society shall have full power and authority, from time to time, to sell, grant, demise, exchange and dispose of absolutely, or by way of mortgage, or otherwise, any of the lands, tenements, hereditaments and possessions, wherein they have any estate or interest, or which they shall acquire as aforesaid, but that no sale, mortgage, or other disposition of any lands, tenements, or hereditaments of the Society shall be made, except with the approbation and concurrence of a General Meeting. And our will and pleasure is, and we further grant and declare that for the better rule

and government of the Society, and the direction and management of the concerns thereof, there shall be a Council of the Society, to be appointed from among the Members thereof, and to include the President and the Vice-Presidents, and such other office-bearers or past office-bearers as may be directed by such Bye-laws as hereinafter mentioned, but so that the Council, including all *ex-officio* Members thereof, shall consist of not more than forty or less than twelve Members, and that the Vice-Presidents shall be not more than six or less than two in number. AND WE DO HEREBY FURTHER will and declare that the said LINDSAY WOOD shall be the first President of the Society, and the persons now being the Vice-Presidents, and the Treasurer and Secretary, shall be the first Vice-Presidents, and the first Treasurer and Secretary, and the persons now being the Members of the Council shall be the first Members of the Council of the Society, and that they respectfully shall continue such until the first election shall be made at a General Meeting in pursuance of these presents. AND WE DO HEREBY FURTHER will and declare that, subject to the powers by these presents vested in the General Meetings of the Society, the Council shall have the management of the Society, and of the income and property thereof, including the appointment of officers and servants, the definition of their duties, and the removal of any of such officers and servants, and generally may do all such acts and deeds as they shall deem necessary or fitting to be done, in order to carry into full operation and effect the objects and purposes of the Society, but so always that the same be not inconsistent with, or repugnant to, any of the provisions of this our Charter, or the Laws of our Realm, or any Bye-law of the Society in force for the time being. AND WE DO FURTHER will and declare that at any General Meeting of the Society, it shall be lawful for the Society, subject as hereinafter mentioned, to make such Bye-laws as to them shall seem necessary or proper for the regulation and good government of the Society, and of the Members and affairs thereof, and generally for carrying the objects of the Society into full and complete effect, and particularly (and without its being intended hereby to prejudice the foregoing generality), to make Bye-laws for all or any of the purposes hereinafter mentioned, that is to say: for fixing the number of Vice-Presidents, and the number of Members of which the Council shall consist, and the manner of electing the President and Vice-Presidents, and other Members of the Council, and the period of their continuance in office, and the manner and time of supplying any vacancy therein; and for regulating the times at which General Meetings of the Society and Meetings of the Council shall be held, and for convening the same and regulating the proceedings thereat, and

for regulating the manner of admitting persons to be Members of the Society, and of removing or expelling Members from the Society, and for imposing reasonable fines or penalties for non-performance of any such Bye-laws, or for disobedience thereto, and from time to time to annul, alter, or change any such Bye-laws so always that all Bye-laws to be made as aforesaid be not repugnant to these presents, or to any of the laws of our Realm. AND WE DO FURTHER will and declare that the present Rules and Regulations of the Society, so far as they are not inconsistent with these presents, shall continue in force, and be deemed the Bye-laws of the Society until the same shall be altered by a General Meeting, provided always that the present Rules and Regulations of the Society and any future Bye-laws of the Society so to be made as aforesaid shall have no force or effect whatsoever until the same shall have been approved in writing by our Secretary of State for the Home Department. IN WITNESS WHEREOF WE HAVE CAUSED THESE OUR LETTERS TO BE MADE PATENT.

Witness Ourself at our Palace, at Westminster, this 28th day of November, in the fortieth year of our reign.

By Her Majesty's Command.

CARDEW.

THE NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

BYE-LAWS

PASSED AT A GENERAL MEETING ON THE 16TH JUNE. 1877.

1.—The members of the North of England Institute of Mining and Mechanical Engineers shall consist of four classes, viz.:—Original Members, Ordinary Members, Associate Members, and Honorary Members, with a class of Students attached.

2.—ORIGINAL MEMBERS shall be those who were Ordinary Members on the 1st of August, 1877.

3.—ORDINARY MEMBERS.—Every candidate for admission into the class of Ordinary Members, or for transfer into that class, shall come within the following conditions:—He shall be more than twenty-eight years of age, have been regularly educated as a Mining or Mechanical Engineer, or in some other recognised branch of Engineering, according to the usual routine of pupilage, and have had subsequent employment for at least five years in some responsible situation as an Engineer, or if he has not undergone the usual routine of pupilage, he must have practised on his own account in the profession of an Engineer for at least five years, and have acquired a considerable degree of eminence in the same.

4.—ASSOCIATE MEMBERS shall be persons practising as Mining or Mechanical Engineers, or in some other recognised branch of Engineering, and other persons connected with or interested in Mining or Engineering.

5.—HONORARY MEMBERS shall be persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society.

6.—Students shall be persons who are qualifying themselves for the profession of Mining or Mechanical Engineering, or some other of the recognised branches of Engineering, and such persons may continue Students until they attain the age of twenty-three years.

7.—The annual subscription of each Original Member, and of each Ordinary Member who was a Student on the 1st of August, 1877, shall be £2 2s., of each Ordinary Member (except as last mentioned) £3 3s., of each Associate Member £2 2s., and of each Student £1 1s., payable in advance, and shall be considered due on election, and afterwards on the first Saturday in August of each year.

8.—Any Member may, at any time, compound for all future subscriptions by a payment of £25, where the annual subscription is £3 3s., and by a payment of £20 where the annual subscription is £2 2s. All persons so compounding shall be Original, Ordinary, or Associate Members for life, as the case may be; but any Associate Member for life who may afterwards desire to become an Ordinary Member for life, may do so, after being elected in the manner described in Bye-law 13, and on payment of the further sum of £5.

9.—Owners of Collieries, Engineers, Manufacturers, and Employers of labour generally, may subscribe annually to the funds of the Institute, and each such subscriber of £2 2s. annually shall be entitled to a ticket to admit two persons to the rooms, library, meetings, lectures, and public proceedings of the Society; and for every additional £2 2s., subscribed annually, two other persons shall be admissible up to the number of ten persons; and each such Subscriber shall also be entitled for each £2 2s. subscription to have a copy of the Proceedings of the Institute sent to him.

10.—In case any Member, who has been long distinguished in his professional career, becomes unable, from ill-health, advanced age, or other sufficient cause, to carry on a lucrative practice, the Council may, on the report of a Sub-Committee appointed for that purpose, if they find good reason for the remission of the annual subscription, so remit it. They may also remit any arrears which are due from a member, or they may accept from him a collection of books, or drawings, or models, or other contributions, in lieu of the composition mentioned in Bye-law 8, and may thereupon constitute him a Life Member, or permit him to resume his former rank in the Institute.

11.—Persons desirous of becoming Ordinary Members shall be proposed and recommended, according to the Form A in the Appendix, in which form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This form must be signed by the proposer and at least five other Members certifying a personal knowledge of the candidate. The proposal so made being delivered to the Secretary, shall be submitted to the Council, who on approving the qualifications shall determine if the candidate is to be presented for ballot, and if it is so deter-

mined, the Chairman of the Council shall sign such approbation. The same shall be read at the next Ordinary General Meeting, and afterwards be placed in some conspicuous situation until the following Ordinary General Meeting, when the candidate shall be balloted for.

12.—Persons desirous of being admitted into the Institute as Associate Members, or Students, shall be proposed by three Members; Honorary Members shall be proposed by at least five Members, and shall in addition be recommended by the Council, who shall also have the power of defining the time during which, and the circumstances under which, they shall be Honorary Members. The nomination shall be in writing, and signed by the proposers (according to the Form B in the Appendix), and shall be submitted to the first Ordinary General Meeting after the date thereof. The name of the person proposed shall be exhibited in the Society's room until the next Ordinary General Meeting, when the candidate shall be balloted for.

13.—Associate Members or Students, desirous of becoming Ordinary Members, shall be proposed and recommended according to the Form C in the Appendix, in which form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This form must certify a personal knowledge of the candidate, and be signed by the proposer and at least two other Members, and the proposal shall then be treated in the manner described in Bye-law 11. Students may become Associate Members at any time after attaining the age of twenty-three on payment of an Associate Member's subscription.

14.—The balloting shall be conducted in the following manner:—Each Member attending the Meeting at which a ballot is to take place shall be supplied (on demand) with a list of the names of the persons to be balloted for, according to the Form D in the Appendix, and shall strike out the names of such candidates as he desires shall not be elected, and return the list to the scrutineers appointed by the presiding Chairman for the purpose, and such scrutineers shall examine the lists so returned, and inform the meeting what elections have been made. No candidate shall be elected unless he secures the votes of two-thirds of the Members voting.

15.—Notice of election shall be sent to every person within one week after his election, according to the Form E in the Appendix, enclosing at the same time a copy of Form F, which shall be returned by the person elected, signed, and accompanied with the amount of his annual subscription, or life composition, within two months from the date of such election, which otherwise should become void.

16.—Every Ordinary Member elected having signed a declaration in the Form F, and having likewise made the proper payment, shall receive a certificate of his election.

17.—Any person whose subscription is two years in arrear shall be reported to the Council, who shall direct application to be made for it, according to the Form G in the Appendix, and in the event of its continuing one month in arrear after such application, the Council shall have the power, after remonstrance by letter, according to the Form H in the Appendix, of declaring that the defaulter has ceased to be a member.

18.—In case the expulsion of any person shall be judged expedient by ten or more Members, and they think fit to draw up and sign a proposal requiring such expulsion, the same being delivered to the Secretary, shall be by him laid before the Council for consideration. If the Council, after due inquiry, do not find reason to concur in the proposal, no entry thereof shall be made in any minutes, nor shall any public discussion thereon be permitted, unless by requisition signed by one-half the Members of the Institute; but if the Council do find good reason for the proposed expulsion, they shall direct the Secretary to address a letter, according to the Form I in the Appendix, to the person proposed to be expelled, advising him to withdraw from the Institute. If that advice be followed, no entry on the minutes nor any public discussion on the subject shall be permitted; but if that advice be not followed, nor an explanation given which is satisfactory to the Council, they shall call a General Meeting for the purpose of deciding on the question of expulsion; and if a majority of the persons present at such Meeting (provided the number so present be not less than forty) vote that such person be expelled, the Chairman of that Meeting shall declare the same accordingly, and the Secretary shall communicate the same to the person, according to the Form J in the Appendix.

19.—The Officers of the Institute, other than the Treasurer and the Secretary, shall be elected from the Original, Ordinary and Associate Members, and shall consist of a President, six Vice-Presidents, and eighteen Councillors, who, with the Treasurer and the Secretary (if Members of the Institute) shall constitute the Council. The President, Vice-Presidents, and Councillors shall be elected at the Annual Meeting in August (except in cases of vacancies) and shall be eligible for re-election, with the exception of any President or Vice-President who may have held office for the three immediately preceding years, and such six Councillors as may have attended the fewest Council Meetings during the past

year; but such Members shall be eligible for re-election after being one year out of office.

20.—The Treasurer and the Secretary shall be appointed by the Council, and shall be removable by the Council, subject to appeal to a General Meeting. One and the same person may hold both these offices.

21.—Each Original, Ordinary, and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members suitable to fill the offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. (See Form K in the Appendix.) A copy of this list shall be posted at least seven days previous to the Annual Meeting, to every Original, Ordinary, and Associate Member; who may erase any name or names from the list, and substitute the name or names of any other person or persons eligible for each respective office; but the number of persons on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The Votes for any Members who may not be elected President or Vice-Presidents shall count for them as Members of the Council. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the Meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

22.—In case of the decease or resignation of any Officer or Officers, the Council, if they deem it requisite that the vacancy shall be filled up, shall present to the next Ordinary General Meeting a list of persons whom they nominate as suitable for the vacant offices, and a new Officer or Officers shall be elected at the succeeding Ordinary General Meeting.

23.—The President shall take the chair at all meetings of the Institute, the Council, and Committees, at which he is present (he being *ex-officio* a member of all), and shall regulate and keep order in the proceedings.

24.—In the absence of the President, it shall be the duty of the senior Vice-President present to preside at the meetings of the Institute, to keep order, and to regulate the proceedings. In case of the absence of the President and of all the Vice-Presidents, the meeting may elect any Member of Council, or in case of their absence, any Member present, to take the chair at the meeting.

25.—The Council may appoint Committees for the purpose of transacting any particular business, or of investigating specific subjects connected with the objects of the Institute. Such Committees shall report to the Council, who shall act thereon as they see occasion.

26.—The Treasurer and the Secretary shall act under the direction and control of the Council, by which body their duties shall from time to time be defined.

27.—The Funds of the Society shall be deposited in the hands of the Treasurer, and shall be disbursed or invested by him according to the direction of the Council.

28.—The Copyright of all papers communicated to, and accepted for printing by the Council, and printed within twelve months, shall become vested in the Institute, and such communications shall not be published for sale or otherwise, without the written permission of the Council.

29.—An Ordinary General Meeting shall be held on the first Saturday of every month (except January and July) at two o'clock, unless otherwise determined by the Council; and the Ordinary General Meeting in the month of August shall be the Annual Meeting, at which a report of the proceedings, and an abstract of the accounts of the previous year, shall be presented by the Council. A Special General Meeting shall be called whenever the Council may think fit, and also on a requisition to the Council, signed by ten or more Members. The business of a Special Meeting shall be confined to that specified in the notice convening it.

30.—At meetings of the Council, five shall be a quorum. The minutes of the Council's proceedings shall be at all times open to the inspection of the Members.

31.—All Past-Presidents shall be *ex-officio* Members of the Council so long as they continue Members of the Institute, and Vice-Presidents who have not been re-elected or have become ineligible from having held office for three consecutive years, shall be *ex-officio* Members of the Council for the following year.

32.—Every question, not otherwise provided for, which shall come before any Meeting, shall be decided by the votes of the majority of the Original, Ordinary, and Associate Members then present.

33.—All papers shall be sent for the approval of the Council at least twelve days before a General Meeting, and after approval, shall be read before the Institute. The Council shall also direct whether any paper read before the Institute shall be printed in the Transactions, and notice shall be given to the writer within one month after it has been read, whether it is to be printed or not.

34.—All proofs of reports of discussions, forwarded to Members for correction, must be returned to the Secretary within seven days from the date of their receipt, otherwise they will be considered correct and be printed off.

35.—The Institute is not, as a body, responsible for the statements and opinions advanced in the papers which may be read, nor in the discussions which may take place at the meetings of the Institute.

36.—Twelve copies of each paper printed by the Institute shall be presented to the author for private use.

37.—Members elected at any meeting between the Annual Meetings shall be entitled to all papers issued in that year, so soon as they have signed and returned Form F, and paid their subscriptions.

38.—The Transactions of the Institute shall not be forwarded to Members whose subscriptions are more than one year in arrear.

39.—No duplicate copies of any portion of the Transactions shall be issued to any of the Members unless by written order from the Council.

40.—Invitations shall be forwarded to any person whose presence at the discussions the Council may think advisable, and strangers so invited shall be permitted to take part in the proceedings but not to vote. Any Member of the Institute shall also have power to introduce two strangers (see Form L) to any General Meeting, but they shall not take part in the proceedings except by permission of the Meeting.

41.—No alteration shall be made in the Bye-laws of the Institute, except at the Annual Meeting, or at a Special Meeting for that purpose, and the particulars of every such alteration shall be announced at a previous Ordinary Meeting, and inserted in its minutes, and shall be exhibited in the room of the Institute fourteen days previous to such Annual or Special Meeting, and such Meeting shall have power to adopt any modification of such proposed alteration of the Bye-laws.

Approved,
R. ASSHETON CROSS.

Whitehall,
2nd July, 1877.

APPENDIX TO THE BYE-LAWS.

[FORM A.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being upwards of twenty-eight years of age, and desirous of being elected an Ordinary Member of the North of England Institute of Mining and Mechanical Engineers, I recommend him from *personal knowledge* as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-law 3.*]

On the above grounds, I beg leave to propose him to the Council as a proper person to be admitted an Ordinary Member.

Signed_____Member.

Dated this day of 18

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted an ordinary Member.

FROM PERSONAL KNOWLEDGE.

_____
_____
_____
_____
_____ } Five Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a of the North of England Institute of Mining and Mechanical Engineers.

Signed_____Chairman.

Dated this day of 18

[FORM B.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being desirous of admission into the North of England Institute of Mining and Mechanical Engineers, we, the undersigned, propose and recommend that he shall become [an Honorary Member, or an Associate Member, or a Student] thereof.

_____
_____
_____ } Three* Members.
_____
_____

* If an Honorary Member, five signatures are necessary, and the following Form must be filled in by the Council.

Dated this day of 18

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Honorary Member of the North of England Institute of Mining and Mechanical Engineers.

Signed _____ Chairman.

Dated day of 18

[FORM C.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being at present a of the North of England Institute of Mining and Mechanical Engineers, and upwards of twenty-eight years of age, and being desirous of becoming an Ordinary Member of the said Institute, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the Qualifications of the Candidate according to the spirit of Bye-law 3.*]

On the above grounds, I beg leave to propose him to the Council as a proper person to be admitted an Ordinary Member.

Signed _____ Member.

Dated this day of 18

We, the undersigned, concur in the above recommendation, being

convinced that A. B. is in every respect a proper person to be admitted an Ordinary Member.

FROM PERSONAL KNOWLEDGE.

_____ } Two
_____ } Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Ordinary Member of the North of England Institute of Mining and Mechanical Engineers.

Signed _____ Chairman.

Dated day of 18

[FORM D.]

List of the names of persons to be balloted for at the Meeting on , the day of 18

ORDINARY MEMBERS:—

_____

_____

_____

ASSOCIATE MEMBERS:—

_____

_____

HONORARY MEMBERS:—

_____

_____

STUDENTS:—

_____

_____

Strike out the names of such persons as you desire should *not* be elected, and hand the list to the Chairman.

[FORM E.]

SIR,—I beg leave to inform you that on the day of you were elected a of the North of England Institute of Mining and Mechanical Engineers, but in conformity with its Rules your election cannot be confirmed until the enclosed form be returned to me

with your signature, and until your first annual subscription be paid, the amount of which is £ , or, at your option, the life-composition of £

If the subscription is not received within two months from the present date, the election will become void under Bye-law 15.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM F.]

I, the undersigned, being elected a of the North of England Institute of Mining and Mechanical Engineers, do hereby agree that I will be governed by the Charter and Bye-laws of the said Institute for the time being; and that I will advance the objects of the Institute as far as shall be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to be a Member.

Witness my hand this day of 18

[FORM G.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to draw your attention to Bye-law 17, and to remind you that the sum of £ of your annual subscriptions to the funds of the Institute remains unpaid, and that you are in consequence in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Article above referred to.

I am, Sir,

Yours faithfully,

Secretary

Dated 18

[FORM H.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you, that in consequence of non-payment of your arrears of subscription, and in pursuance of Bye-law 17, the Council have determined that unless payment of the amount £ is made previous to the day of next, they will proceed to declare that you have ceased to be a Member of the Institute.

But, notwithstanding this declaration, you will remain liable for payment of the arrears due from you.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM I.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you that, upon mature consideration of a proposal which has been laid before them relative to you, they feel it their duty to advise you to withdraw from the Institute, or otherwise they will be obliged to act in accordance with Bye-law 18.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM J.]

SIR,—It is my duty to inform you that, under a resolution passed at a Special General Meeting of the North of England Institute of Mining and Mechanical Engineers, held on the day of 18 , according to the provisions of Bye-law 18 you have ceased to be a Member of the Institute.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM K.]

BALLOTING LIST.

Ballot to take place at the Meeting of _____ 18 _____ at Two o'Clock.

PRESIDENT—ONE NAME only to be returned, or the vote will be lost.

_____ President for the current year eligible for re-election.

_____ } New Nominations.
_____

VICE-PRESIDENTS—SIX NAMES only to be returned, or the vote will be lost.

The Votes for any Members who may not be elected as President or Vice-Presidents will count for them as other Members of the Council.

_____ } Vice-Presidents for the current year eligible for re-election.
_____
_____
_____

_____ } New Nominations.
_____
_____
_____

COUNCIL—EIGHTEEN NAMES only to be returned, or the vote will be lost.

_____ } Members of the Council for the current year eligible for re-election.
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

_____ } New Nominations.
_____
_____
_____
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Any list returned with a greater number of Names than
ONE PRESIDENT,
SIX VICE-PRESIDENTS,
EIGHTEEN COUNCILLORS,
Will be rejected by the Scrutineers as informal, and the Votes will consequently be lost.

Extract from Bye-law 21.

Each Original, Ordinary, and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members suitable to fill the Offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. (see Form K in the Appendix.) A copy of this list shall be posted at least seven days

previous to the Annual Meeting, to every Original, Ordinary, and Associate Member; who may erase any name or names from the list, and substitute the name or names of any other person or persons eligible for each respective office; but the number of persons on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The votes for any Members who may not be elected President or Vice-Presidents shall count for them as Members of the Council. The Chairman shall appoint four Scrutineers, who shall receive the balloting papers, and after making the necessary scrutiny destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the Meeting, so as to be received before the appointment of the Scrutineers for the election of Officers.

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Names substituted for any of the above are to be written in the blank spaces opposite those they are intended to supersede.

The following Members are ineligible from causes specified in Bye-law 19:—

As President _____

As Vice-President _____

As Councillors _____

[FORM L.]

Admit

of

to the Meeting on Saturday, the

(Signature of Member or Student)

The Chair to be taken at Two o'Clock.

I undertake to abide by the Regulations of the North of England Institute of Mining and Mechanical Engineers, and not to aid in any unauthorised publication of the Proceedings.

(Signature of Visitor)

Not transferable.

NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING, SATURDAY, OCTOBER 13TH, 1883, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

GEORGE BAKER FORSTER, ESQ., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting, and reported the proceedings of the Council.

The following gentlemen were elected, having been previously nominated:—

ORDINARY MEMBERS—

Mr. JAMES GIBSON DEES, Civil Engineer, Floraville, Whitehaven.
Mr. ATHERTON SELBY, Mining Engineer, Leigh, near Manchester.
Mr. ISRAEL KNOWLES, Mining Engineer, Pearson and Knowles Coal and Iron Company, Limited, Wigan.

ASSOCIATE MEMBER—

Mr. WILLIAM FLETCHER, Brigham Hill, *via* Carlisle.

The following were nominated for election:—

HONORARY MEMBER—

HERR BRASSERT, Chief Inspector of Mines, Germany.

ASSOCIATE MEMBERS—

Mr. D. FERGUSSON, Harrington Colliery, Cumberland.

Mr. BENJAMIN TYZACK, Preston Road, North Shields.

Mr. FRANK MURRAY STILL, 3, Queen Street, Cheapside, London.

Mr. CHARLES FREDERICK WORMALD, Cement Manufacturer, Cross House, Corbridge.

STUDENTS—

Mr. BENJAMIN MCLAREN, Bedlington, Northumberland.

Mr. WILLIAM HAY, Jun., Nostell Colliery, Wakefield.

Mr. HENRY LAWRENCE read the following paper on "The Danger of Sparks produced from Prickers and Stemmers used for Blasting purposes in Coal Mines, and Sparks otherwise produced:"—

THE DANGER OF SPARKS PRODUCED FROM PRICKERS AND STEMMERS USED FOR BLASTING PURPOSES IN COAL MINES, AND SPARKS OTHERWISE PRODUCED.

By HENRY LAWRENCE.

Shortly before the Mines Regulation Act came in force a great demand was made upon brassfounders to supply the copper prickers and stemmers that were ordered to supersede the iron ones then in use. It was generally thought that a great danger would be remedied by this introduction, as every one connected with blasting knew that a spark from the iron rammer might at any moment fire the powder in the act of ramming the charge; the use of copper instead of iron seemed to bring to all a feeling of safety; how many at that time had any idea that the copper prickers and stemmers were very nearly, if not quite, as dangerous as the iron ones? About two years ago the writer received a letter from the manager of a large colliery stating that—"A stoneman working in a whin drift had finished drilling a hole 14 inches deep, and put in a shot one inch diameter and five inches long, and then commenced to stem with black rolleyway dirt. He had only put in one handful of dirt and commenced to use the beater when the powder exploded and seriously burnt the miner." The writer at once proceeded to the colliery and found that the stemmer in question when taken into a dark cabin and struck on the stone slab of the fire-place, produced a spark at every blow. As the stemmer appeared to be made of brass, it was thought that some brass turnings mixed with particles of iron turnings might have been used in its composition and caused the sparks; a set was made entirely of copper, when it was found from experiments made that it also struck fire by impact with a piece of stone; ingot copper was tried with the like result, the fire being clearly visible in a dark room. In case there might be impurities in the copper ingot, a copper bolt was tried with no better success; some stemmers in progress of manufacture were also tried, and sparks were got readily by the same means. The writer was forced to the conclusion that copper would, and did, produce sparks. It transpired afterwards that the new

copper stemmer before alluded to had been tried in a whin drift and found to strike fire at almost every blow. Several other cases could be mentioned but it is unnecessary to describe them. Sets of stemmers made of copper, of the usual cheap composition called brass or phosphor bronze, together with a bolt or bar of copper, were produced; and if members tried them in a small dark tent erected in the hall, they would find that all of them produced distinct sparks from almost every blow on a piece of grindstone. Having become fully aware of the danger of the instruments now in use, the writer, in conjunction with his foreman brassfounder, made several trials and experiments to discover a mixture of metal from which it would be impossible to obtain a spark by impact with the hardest, or in fact any, stone; and stemmers of this composition were also produced, so that members might satisfy themselves as to their fulfilling these conditions. For safety it is suggested that every pricker and stemmer should be tried in a dark room in the manner described before being allowed to enter a mine. In the last report of Her Majesty's Inspectors of Mines, Mr. Henry Hall states that:—"The stemming of charges of gunpowder with copper stemmers has again been proved to be attended with danger, sparks being easily produced from this metal striking against hard substances, such as pyrites, but of course not so readily as from iron and steel, the use of which is forbidden. The remedy appears to be in the use of wooden stemmers where it is practicable." If the remedy pointed out by Mr. Hall is practicable, by all means let it be carried out, but the writer fears wooden stemmers would not stand the hard usage they would be subjected to in this district, although he has no doubt but that a safe and reliable metal pricker and stemmer can be put into the hands of miners who may be engaged in the dangerous practice of blasting.

The following account of a recent accident that has occurred in the district shows the great importance of the question, and would, perhaps, be worth recording in the Transactions:—

GUNPOWDER ACCIDENT.—On Friday, a coal miner named George Anderton, employed at Shire Moor Colliery, met with an accident which it is feared may result in the loss of one, if not both his eyes. It seems that Anderton was stemming a hole in which he had inserted nearly a pound of powder preparatory to shooting down his jud, when the powder unaccountably exploded, the full force of it striking him in the face and forehead. He was, of course, very seriously burnt, in addition to his other injuries. Dr. Alexander, of Earsdon, at once rendered all the assistance the swollen condition of the poor fellow's head would admit of, and he is progressing as well as can be expected. It is well to add that the stemmer he was using was the usual composite metal one, which renders the accident still more inexplicable.

With respect to the second part of this paper, "Sparks otherwise produced," the writer, having passed several nights in a coal mine in South Wales trying a compressed air locomotive engine with iron wheels, found that when the engine sometimes stuck with its load on an incline, the wheels slipped round with great velocity and threw off long streams of sparks; this was considered a source of danger in case of an accumulation of gas (which sometimes occurred in this mine) and the locomotive was condemned unless tyres could be found from which it would be impossible to produce a spark when they were slipping round on the rails. As a number of large horses are used in South Wales for hauling the heavy trams from the face to the main roads, the writer considered there was a large margin of saving in favour of haulage by locomotives if the spark question could be satisfactorily settled, and he therefore made a series of trials with tyres composed of various mixtures of metal. A locomotive was packed up so that the wheels were free to revolve, and an iron rail was placed under one wheel in the form of a lever and weighted so as to take a great portion of the weight of the locomotive; the engine was then started and run at a high velocity. Copper tyres gave out long streams of sparks almost as bad as iron, and instead of the iron rail cutting away the tyre, as was expected, the copper tyre made a slight indentation on the iron rail. This was probably caused by the high speed of the tyres. Other mixtures of various white metals were found too soft, and were rapidly worn away by small fragments flying off. At last a mixture of metal was fixed upon from which the sparkless prickers and stemmers are now made. These tyres produced no sparks, and the writer expects he has found a mixture of metal that will wear sufficiently long to enable them to be economically and safely used on air locomotives in fiery mines. The writer has asked several mining engineers if sparks would ignite gas in a mine, and has received "yes" and "no" in reply, and after calling attention to the old method of using flint and steel, has been told that cases of explosion have been known, or supposed, to have occurred from their use. He has seen sparks produced in mines from the shoes of horses and ponies in striking the rails; also from the iron tips on the miners' shoes, and has been told that sparks are sometimes produced by the blow of the miner's pick. A gentleman who owns some large wood-working machinery informed him that he had a large room in which a number of saw-sharpening machines were at work which produced large volumes of sparks when the emery wheels were in contact with the saws. This room was lighted with gas, which sometimes escaped, and thinking this dangerous, he tried in various ways to ignite gas elsewhere with sparks but did not succeed, and he then came

to the conclusion that it was impossible so to set fire to it. For some considerable time the writer was under the same impression, but he has since found that he could ignite gas from a burner with sparks from a piece of flint and steel, struck over it. Again; he also found that if the gas-burner, with the gas turned on, is placed near an emery wheel placed in a lathe running at about 120 revolutions per minute with a steel tool against it, giving out a stream of sparks, the gas is easily ignited at the spot where the sparks are the hottest; but it is necessary that the brightest and hottest sparks should come near the end of the burner whence the gas is issuing, just as a heated poker must be of a tolerably light red heat and placed near the burner, before it will light gas.

The writer is aware that the gas with which he has experimented is different to that which the mining engineer has to contend with, but hopes in the discussion the following questions will be satisfactorily answered:—

Are sparks dangerous in coal mines? If so, to what extent, and will they ignite the explosive gas found therein?

The SECRETARY read the following communication received from Mr. Sawyer, Assistant Inspector of Mines:—

A small quantity of gas, the pressure of which was not known until it ignited, was fired by a spark from the pick of a fireman who was ripping down some hard piece of roof near a small pot-hole, at the Great Fenton Colliery this year.

I made careful enquiries as to the circumstances of the case, and am fully satisfied that what he stated is correct. He was not touched by the flame, which was small; and had he ignited it in any other way he would not have reported it.

I have, on several occasions, seen sparks fly off from the men's picks when at work, which were very white in appearance; and I cannot help thinking would have ignited gas had any been present.

This shows how necessary it is to completely remove any accumulation of gas, and to keep the pit constantly free from it.

Professor HERSCHEL said, the actual results of the careful and abundant observations of Mr. Lawrence had been quite contrary to all he had gathered from experiments made on a small scale for his own information. The very severe blows and trials these metals had been subjected to by Mr. Lawrence were far beyond the reach of small experimenters, and most clearly demonstrated that the igniting properties of all metals that could be named, under circumstances of mine work, rendered them serious sources of danger. He suggested that the material which Mr. Lawrence had had the good fortune to discover should be used also for the manu-

facture of tools as well as of stemmers. They might now, he thought, almost look upon this as the bronze age; after reaching, as they supposed, the perfection of the iron age, they now found a better age before them. He hoped Mr. Lawrence's metal might be found so serviceable as to come into general use.

Mr. LAWRENCE said, sparks were given off phosphor-bronze quite as readily as off copper.

Mr. WM. SPENCER said, about twenty years ago an explosion took place in Cleveland which was supposed to have been caused by the ignition of the powder by the iron stemmer. He had tools made; one of steel, one of iron, and one of copper, and, with the manager, tried them to a considerable extent. A small quantity of powder was put on a table below, and sparks were produced from the three different tools. He could quite corroborate what Mr. Lawrence had said, but he might add that copper was much safer than iron or steel. Although copper was not absolutely safe, the experiments proved it was a great protection and safeguard.

Mr. W. COCHRANE asked Mr. Lawrence what was the relative degree of hardness of his metal, and whether it was contemplated using it for any other purpose than stemmers?

Mr. STEAVENSON said the question asked by Mr. Lawrence, "Are sparks dangerous in coal mines?" seemed to him to be worth most serious consideration. It depended very much upon circumstances—of what did sparks consist? They consisted of small particles struck off the materials in contact with such force as to raise them to a white heat. If the spark was of such a character as to give out sufficient heat, it would cause an explosion, otherwise it would not be dangerous; for although some explosions were attributed to the sparks issuing from the old flint and steel mill, yet that system of lighting had been largely used without causing accidents. He thought the value of a safe stemmer was of more importance in connection with the use of powder than in respect of gas. In the Cleveland district a large quantity of blasting powder was used. Three-quarters of a ton of powder a day was used in Bell Brothers' mines, and that large quantity had to be put into holes and stemmed in four-ounce "tots;" and, although accidents had been numerous, he had been surprised that they had not been more so under the circumstances in which the men had been working. If Mr. Lawrence had found a material which would give absolute safety, he deserved the thanks of every one present. He had examined the new stemmers produced, and they appeared

to be made of an exceedingly soft metal, which was perhaps the reason of its increased safety, and which approximated more nearly to the hardness of wood than any of the other stemmers on the table; if they tried it with a knife they would find it was easily indented. Had Mr. Lawrence ever tried it against emery in a lathe? He had invited Mr. Toyn, the President of the Cleveland Miners' Association, to be present, and would like to hear what that gentleman had to say on the subject.

Mr. Toyn said, that as the question of stemmers was to be brought before the meeting, Mr. Steavenson had kindly invited him to attend. He thought that great credit was due to Mr. Lawrence if he had discovered a material which could be made into stemmers which would not create a spark. He could quite understand that gentlemen who laboured in colliery districts, more especially where they had to contend with gas in mines, would be desirous to have every material of the safest and best kind. Although there was not so much gas in the Cleveland mines, yet the men were continually handling gunpowder. From 1,200 to 1,300 tons of blasting powder was used in the Cleveland district every year; it was charged in holes to the extent of ¼ lb. to 2½ lbs. There had been several very serious cases where men had been shot, and they tried to trace out the cause, which it was difficult to do in many cases. In one of Bell Brothers' mines at Carlinhow, a few weeks ago, a man was charging a hole in the ordinary way, without using any force; he just put in the powder, and threw in dirt with one hand, and was stemming it carefully down with the other, when it exploded. The man was injured, but had since recovered. They were anxious to find out the cause of that explosion, whether it was the powder or whether it was the stemmer. The powder was sent to a public analyist, who analysed it, and declared it was very safe. Bell Brothers, he believed, were having the stemmer tested, to find out whether there was anything more dangerous in it than common. He had had considerable correspondence with Colonel Majendie on this question, and that gentleman had sent him a pamphlet containing a series of experiments with copper, phosphor-bronze, and different kinds of material, and the experiments showed that phosphor-bronze was the safest material to use. Number 7 or 8 hard phosphor-bronze in experiments on a wheel of free grit stone, turning at something like 1,200 revolutions per minute, gave off only one spark. They met the Cleveland mine owners and asked them to take into consideration the using of phosphor-bronze, and some of them had, he believed, ordered sets of gear to make a trial. If Mr. Lawrence had discovered a material

even safer than the hard phosphor-bronze, it would be one of the best things ever heard of; but the material must be durable, for it would have to be put to a great test, especially in the Cleveland mines where the stemming was hard and the holes frequently 4 feet deep; it must also be a material that could be easily repaired. The Cleveland mine owners had said that cost was no matter if a material could be obtained that was safe. He, as representing the miners in the Cleveland district, thanked Mr. Lawrence for his discovery, and hoped the material would be used throughout the mining districts.

The PRESIDENT asked if the material was a casting, and, if broken, whether it would be of any use or would have to be re-melted? Was the composition of it a secret?

Mr. STEAVENSON said, one cause of danger in stemming the three-cornered holes usually made in Cleveland is that after the powder and the hay plug are put in, there is a considerable quantity of powder left on the bottom of the hole when the stemming is commenced, and this formed a train which, when ignited by a spark, fired the charge. If the men, after putting in the hay plug, examined the hole and drew out all the loose powder it would contribute much to their safety.

Mr. BIRD said, it was a notorious fact that sparks could be produced otherwise than by contact between metal and stone. They could be produced by contact between stone and stone. If powder was being rammed down home and stones were violently disturbed by the impact of the stemmer, the particles of stone were brought into contact with each other, and sparks could be produced in that way.

Mr. LAWRENCE said, the first question asked by Mr. Cochrane was as to the hardness of the material; he also asked whether Professor Herschel was right in imagining that the material was intended for tools other than stemmers. The material was not intended, so far as he was concerned, to make anything in the shape of miners' tools excepting prickers and stemmers. There would, of course, be many other uses for it in gunpowder factories. The material was not quite, but very nearly, as hard as copper; there was not so much difference as might be inferred from Mr. Steavenson's remarks. Mr. Steavenson had asked whether he had ever tried the material on an emery wheel. He had tried a small disc in the lathe, in the same way that they tested the other disc; but the greatest test was on the locomotive wheels. The tyres were made and put on, and the engine was run at perhaps 300 or 400 revolutions a minute, and not a single spark was given out, whereas a long stream of sparks was

given off by the copper tyres. The President had asked whether the stemmers were castings. They could be easily cast in moulds. They were at present cast in sand in the ordinary way. The material was such that the amalgamation or construction of the metal would not be altered by re-melting. He did not know that it would be possible, as Mr. Toyn suggested, that the stemmers could be mended. They could draw out copper prickers by fire; but ordinary composition stemmers, generally speaking, could not be mended by drawing them. He imagined this material would draw out, although he had not tested it; but it could be put into the fire, burnt together, and repaired the same as copper. He could easily imagine that sparks could be produced as Mr. Bird suggested, but he certainly had been astonished at the ignition of gas by such sparks and by those from a flint and steel; in fact he must say it was a surprise to him to see an ordinary street-lamp lighted with a red-hot poker. If instead of using the flint and steel, an old file and a piece of flint stone were used, and the gas burner held to them with the gas turned on, the sparks readily ignited the gas. He tried this several times, and succeeded quite easily when he got into the knack of doing it. When a wooden box was put over the emery wheels and a piece of steel inserted, with a gas-pipe placed in one end of the box at some distance from the sparks, the gas was not ignited; but when the gas-pipe was put immediately underneath the emery wheel, so that the sparks ran direct into the gas-pipe orifice, the gas was lighted as easily as with a piece of lighted paper.

The PRESIDENT asked whether any of these prickers and stemmers had been tried in ironstone mines, or only in coal mines.

Mr. LAWRENCE said they had not been tried in ironstone mines, neither had they been tried very much in coal mines. He sent a set to a gentleman who stated that he had tried them in every way and could not get any spark, even when put to all the severe tests possible. So far, he was satisfied it was impossible to get a spark, unless it was produced with stone against stone, which was very different from the ordinary bar of copper or phosphor-bronze, which, when struck in a dark cabin, would produce sparks at every blow.

Mr. J G. WEEKS said, they would almost imagine from the concluding remarks of Mr. Lawrence, that the use of copper was highly dangerous. The very contrary was found in practice. He had 300 men working in a pit, and 400 shots were fired in that pit every day, 100 stone shots (blue metal and post girdles), and 300 coal shots; copper had been used for the last ten years, and in all that time only one man had been burnt.

In this case he had the hole cut with a saw, and found a piece of iron pyrites on one side of it in which the powder had ignited; but whether it was the copper beater against the pyrites, or two pieces of pyrites which caused the accident, he was unable to determine. He was inclined to think with Mr. Bird, it was the pieces of pyrites in the hole being brought into contact with each other by the beater, which caused the man to be burnt, if the workman was really "stemming" and not "unramming" the shot, which could not be satisfactorily established at the time of its occurrence; so that, after his experience, he felt there was very little danger in continuing to use copper beaters and prickers. He had experimented with Muntz's metal, and found it gave sparks freely; but he found copper did not emit sparks nearly so readily.

The PRESIDENT said, the reason he asked whether these stemmers were castings or could be drawn, was that it was the great disadvantage of ordinary castings of bronze or brass that, when broken, the stemmer was of no further use. For that reason, after having tried many experiments, they adopted Muntz's metal in 1872, as being much the same as copper; and it had been used since. He did not think any accident had occurred. They had not these things ready when the Act came into operation, and wood was used for a time and found useful. He did not know whether it would not be well to use wood stemmers in coal mines. As to firing gas, they knew that sparks would fire gas. The old steel mill was not safe, and did fire gas. Their forefathers thought that picks gave off sparks. In the explorations after the great explosion at the Felling, it was necessary to drive a wall where some gas had accumulated, and that wall was driven by wooden picks, which showed they were afraid of using iron or steel picks at that time. He moved a vote of thanks to Mr. Lawrence for the paper.

Mr. JOHN MARLEY seconded the vote of thanks and suggested that Mr. Lawrence should present one or two sets of prickers and stemmers to Mr. Steavenson for trial in the Cleveland mines.

Mr. LAWRENCE thanked them for the vote. He was sure that his Company would be very pleased to send two or three sets of prickers and stemmers to Mr. Steavenson for trial, if Mr. Steavenson would let him know the size of the ones he used. He thought in the Cleveland mines, they put the powder in a sort of copper tube, with a piston in it, which was put to the back of the hole, and the powder pressed forward by the piston in the tube. That seemed to him to be a good system, because it prevented the loose powder being in any

part of the hole except the back part. As to wooden stemmers, they might be made of some very hard wood, such as he had seen in Australia, called iron wood; but even then they would not stand very many blows before they were split up, although they would be tolerably cheap.

Mr. STEAVENSON said, the charging tubes Mr. Lawrence referred to could only be used in round holes. In Cleveland the holes were three-cornered; and of those driven by hand not one in a hundred was true.

The SECRETARY read the following paper by Mr. Frank Murray Still, on "Mining Coal by Compressed Lime:"—

ON MINING COAL BY COMPRESSED LIME.

By FRANK MURRAY STILL.

In bringing this method of coal-getting before the members of the Institute, the writer will preface his remarks by stating that it is a system of mining coal patented by Messrs. Sebastian Smith and Moore of the Shipley Collieries, near Derby.

The system has for its objects; firstly, to take the place of blasting by gunpowder or other explosives, thereby giving absolute immunity from all risk of accidents caused by the ignition of gas by a shot, and also by superseding the arduous process of breaking down the coal by wedges, to provide the collier with a system of coal-getting which will enable him to avoid the numerous, and in many cases fatal, accidents which so constantly occur from falls of coal and roof while he is working at the face; secondly, to enable the coal owner to obtain a greatly increased percentage of large coal from a given area; and, thirdly, to diminish in a great measure the laborious work of the collier, where wedging is practised.

The present mode of operating is to employ nearly pure carbonate of lime. The stone at present used, similar to that of Whitburn, contains 98·40 per cent. of carbonate, and after being carefully calcined is ground to a fine powder. This is conducted to a hydraulic press, specially designed and patented, having a die $2\frac{1}{2}$ inches in diameter and 7 inches deep. A pressure of 40 tons is applied simultaneously to both ends of the column of ground lime, which reduces it from 7 inches to $4\frac{1}{4}$ inches in length, thus nearly doubling its density. A projection in the die forms a groove on the side of the cartridge about half-an-inch in diameter. These blocks or cartridges are immediately packed into specially constructed air-tight boxes, and are then ready to be conveyed to the mine for use.

The shot holes are first drilled by means of a light boring machine, and an iron tube about half-an-inch in diameter, having a small external

channel or groove on the upper side, and provided also with perforations, is then inserted along the whole length of the borehole. This tube is enclosed in a bag of calico, which covers the perforations and one end, and has a tap fitted on the other end. The cartridges are then inserted and lightly rammed so as to ensure their filling the borehole.

After the cartridges have been enclosed by tamping, in the same way as with gunpowder, a small force pump is connected with the tap at the end of the tube by means of a short flexible pipe, and a quantity of water, equal in bulk to the quantity of lime used, is forced in. The water, being driven to the far end of the shot hole through the tube, escapes along the groove and through the perforations and the calico, flowing towards the tamping into the lime, saturating the whole of the charge, and driving out the air before it. The tap is then closed so as to prevent the escape of the steam generated by the action of the water on the lime, and the flexible pipe attached to the pump is disconnected.

Experience has shown that after introducing the water there is always an interval before the steam attains a high pressure, so that all danger can be avoided.

The action of the steam first takes place, cracking the coal away from the roof, and this is followed by the expansive force of the lime.

The blocks, when slaked in an unconfined space, will occupy about five times their original bulk.

It has been stated that the heat produced by the slaking of the cartridges is sufficient to ignite paper should it be rammed into the hole, that it often charred the coal itself, and that the heat was sufficient to ignite gas. As to all these points, important as they assuredly are, Sir Frederick Abel, one of the Royal Commissioners on Accidents in Mines, has, after experiment, expressed himself as satisfied that this is impossible, and in reference to the ignition of gas, it has been found that the maximum heat produced by the slaking of the lime is 700 degrees, whereas it requires a temperature of 2,000 degrees to ignite gas.

The sprags are left in under the coal so as to allow the force to exert itself as far back as possible, and in many instances the coal is forced off and falls for a distance of several inches behind the end of the drilled holes. In some minutes, varying according to the hardness of the seam, on the removal of the sprags, the coal falls clean from the roof in large pieces ready for loading, making little small. The collier can, if convenient, remove two or three sprags at a time, and let down as much as he requires for loading, leaving the rest to remain spragged till wanted. In places with bad roofs this is of course specially advantageous.

The following are among the principal advantages claimed for the system:—

Absolute immunity from explosion from gas, there being no fire or flame.

There is no smoke.

The roof is not shaken. No vacuum is created as is the case with a blown out shot.

Skilled labour is unnecessary, and the coal can be got with much less exertion to the collier than by hand wedging.

The following statement of the comparative working of two stalls adjoining one another, is given as a fair average specimen of the economy of labour and the increased output of large coal resulting from the use of this process, not only at the Shipley Collieries, but in many other districts.

COMPARATIVE RESULT OF LIME PATENT AND WEDGING AT SHIPLEY COLLIERIES.

Date.	Hand Wedging. No. 2 Stall, Woodside Pits.		Lime Patent. No. 1 Stall, Woodside Pits.	
	Hours of Labour.	Tons got.	Hours of Labour.	Tons got.
Week ending Jan. 25, 1882 ...	96¾	225	58	274
Week ending Feb. 1, 1882	100	178	71	236
Week ending Feb. 8, 1882	123	225	90	258
	319¾	628	219	768

140 tons more coal were thus got with 100 hours less labour by the use of the Lime process.

Thus far, the writer has alluded principally to the commercial value of this method of coal-getting, and the profit to all concerned resulting therefrom; but it is the chief merit of the process, and certainly the claim, which of all others, its inventors put forward with the greatest pride (a claim recognised by the various Government Inspectors and those responsible for the lives of miners) that it enables the collier to carry on his work with much less danger than now.

Mr. Laverick, the manager of the Rainton Collieries, belonging to the Marquis of Londonderry, will be happy to show the mode of working with the lime to any of the members of the Institute.

Mr. STILL, in supplementing the paper, said, that lately experiments had been made at the Shipley Collieries in ripping the roof, and had been attended with great success. They did not think the lime had sufficient strength to get the stone, which was very hard; but they found the experiment was successful. He would be glad to answer any further questions that might be asked.

Mr. J. G. WEEKS said, that about this time last year lime cartridges were tried at Bedlington colliery. They were tried in long-wall, and board and wall, and then in the bottom stone of the yard seam. Many viewers of Northumberland were present, and none of them thought the lime suitable to work either long-wall or board and wall, so far as that particular seam was concerned. The time occupied in breaking down the coal was very great, and the time the hewers were underground was too short to allow them to go into another board for half or three-quarters of an hour while the lime was operating; besides the cost of it was about three times the cost of powder, so far as they had tried it. As to making less small, his experiments were not as accurate as he would liked to have had them; but rather more small coals were made with lime than with powder. He stated this with a certain amount of reservation, because he would have liked to have had a longer experiment to speak definitely. They tried lime on the bottom stone, and there were, he thought, the elements of success in it; and it was his intention to try lime again to see if he could not loosen the bottom stone to make it easier for the men to hew out. That was where he expected lime would be of the greatest use. The seam he was speaking of was hard, and where they were allowed to use powder, having no gas.

Mr. RICHARD FORSTER said he did not know but that the lime process might in some instances be eminently successful; but he would like some information as to whether it was claimed for this process that, under all conditions, it was absolutely successful in getting coal down. The writer stated that "in many instances the coal is forced off, and falls for a distance of several inches beyond the end of the drilled holes." Did that follow when there was no nicking and kirving made? As to immunity from danger, his experience told him that if this process was put into the hands of unskilled men there would be more accidents than in the using of powder. There might be no smoke, but he was not satisfied, he spoke with reserve, that the smell arising from it would not, in some instances, be more objectionable than smoke itself. He asked whether, in all the instances in which the lime was tried in Durham, it had removed all the coal specially prepared by kirving and nicking?

Mr. WEEKS said, at Bedlington the lime did not remove the coal for several inches behind the holes, but the reverse; three to five inches of hole were left on.

Mr. RICHARD FORSTER—Are there not some instances known to the gentlemen representing the Lime Cartridge Company where the coal was not removed at all?

Mr. STEAVENSON said, that with Messrs. Bell Brothers it had been quite a failure. In a board of the ordinary character, at Tursdale Colliery, he spent three or four hours watching, and the coal was quite untouched, and the men admitted they could not do anything with it. He suggested that the discussion of this paper be adjourned until the promised paper on "Wedging" was before the members.

Mr. LOGAN said, this lime process was a very old one. One of the oldest managers in the county of Durham told him that fifty years ago men in the colliery under him used lime to lift the bottom, which was damp, where they were not allowed to use powder. They stemmed the bottom with dry lime at night, and in the morning it did sometimes ease them in lifting the bottom. It was also used by the manager in the coal; but its action was uncertain, and when it did act the lime splashed all over. They did not find that the use of lime cartridges was increasing in Durham. He would like to know from the author of the paper whether all the collieries that adopted the process were continuing it. They were told that at one colliery lime cartridges were being used to a large extent, and that they resulted in a considerable saving as compared with the use of the wedge. Was that the hand or machine wedge? An experiment had been made at a colliery, in a seam 4 feet, a wall 9 feet wide was nicked and kirved 3 feet 6 inches; four holes put in with three cartridges in each hole, in all twelve cartridges, and they failed to make the slightest impression on the jud. Another trial was made in a board 6 feet wide, nicked and kirved 3 feet 6 inches, three holes put in with three cartridges in each hole; the jud gave slightly next the nicking, and about two tubs of coal could be taken off with the pick, but the remainder of the jud was unaffected. In all the experiments he had heard of that seemed to be the result. There was no certainty of action. As Mr. Weeks said, the hewer could not wait. They wanted something quicker. They wanted something safe by all means; but they wanted something quicker than lime.

Mr. STILL, in reply, said that, with respect to the percentage of large or round coal got by the use of the lime, Mr. Laverick, the Manager of the Rainton Colliery, told him on the previous day that the percentage

of large coal was 15 to 20 per cent. more than that got by hand wedging. As to coal being got beyond the depth of the hole, that frequently occurred at Shipley and elsewhere, where they left the coal on the sprags and it came down eighteen inches behind the hole itself. Another point, raised by Mr. Richard Forster, was as to the steam from the lime being dangerous to the men. That was an objection that was raised by the colliers at Rainton, and the matter was brought before their council. At the request of Mr. Laverick the council examined the place, and reported that there was nothing to complain of in the matter. As to the cost, Mr. Laverick distinctly told him on the previous day, and in fact authorized him to mention it at this meeting, that the cost of the lime process was considerably cheaper than the present system of wedging by hand. A gentleman present had spoken of experiments made with three cartridges in each hole. He really did not think it fair that a system, in connection with which it was distinctly stated seven cartridges went to a shot, should be tried with not half the power; and it was from trials of this class that the more unsatisfactory results were obtained. In some places they could do with six cartridges in a hole, but they used seven as a rule.

Mr. Logan said that in the case he mentioned there were four holes, each with three cartridges, making twelve.

The President—Mr. Still says there should be seven cartridges in each hole.

Mr. Richard Forster asked whether Mr. Still claimed for this system that it was universally effective in getting coal under all conditions? They could not make their coal to suit the lime cartridges. They wanted the lime cartridges to suit their coal.

Mr. Steavenson proposed a vote of thanks to Mr. Still for the paper, and said this was a matter which deserved their attention, even if they were not satisfied one way or another.

Mr. May seconded the vote of thanks, and suggested that the further discussion of the paper should be postponed until the next meeting.

Mr. Still thanked the meeting for the vote of thanks, and stated that the best evidence he could give as to the use of lime as a means of coal-getting was the number of letters he had received from various colliery managers in that and other districts, all the letters having been written after practical experiments with the cartridges.

The meeting then concluded.

SOME RESULTS OF THE OBSERVATIONS ON UNDERGROUND TEMPERATURE DURING THE CONSTRUCTION OF THE ST. GOTHARD TUNNEL.

By Dr. F. STAPFF.

Communicated by Professor G. A. Lebour, M.A., F.G.S.

Taken as read at the General Meeting held on June 9th, 1883.

It is not the writer's intention to recapitulate here the observations of nine years, which are registered in the "Geologische Durchschnitte des Gothard Tunnels," nor the brief summaries and conclusions hitherto drawn from these observations, but only to mention some few results obtained, which seem to be worthy of attention.

The diagrams on the distribution of temperature in the great tunnel, published as "Annexe" XIV. to Vol. VIII. of the "Rapports Trimestriels du Conseil fédéral Suisse sur la marche de l'Entreprise du chemin de fer du Gothard," show some curious irregularities, which may depend on the considerable influences of cold water on the south side, on warm springs in the neighbourhood of the serpentine, on the decomposition of rock near faults, or on different heat conductivities of the different rocks, but above all they should be ascribed to the configuration of the ground and to its different surface temperatures at different points.

The surface temperatures of ground as determined by continued observations on a certain class of springs up to 2,600 metres above sea level increase southward and decrease upwards. The empirical relation is

$$\theta = 6{\cdot}734 + 0{\cdot}0001096\ D - 0{\cdot}004256\ (H - 1{,}100),$$

where θ = temperature of ground, 112 metres below surface, in degrees Centigrade.

D = distance from northern mouth of tunnel southwards in metres.

H = height of point above sea level in metres.

On the other hand the empirical relation between temperature of air (T), D and H was found to be

$$T = 5{\cdot}45 + 0{\cdot}000075\ D - 0{\cdot}007024\ (H - 1{,}100).$$

A combination of both formulas shows that the difference $\Delta = \theta - T$ increases as the temperature decreases; that difference being about $1\frac{1}{2}^\circ$ if θ be 7° and 6° if $\theta = 1^\circ$, or generally

$$\Delta = 3{\cdot}74 - 0{\cdot}411\ T - 0{\cdot}0029\ T^2.$$

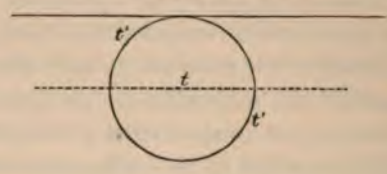
A quite similar result was arrived at by computing the observations on the temperature of air and of springs at twenty-two localities between Lapland, Congo, and Cumana, viz.:—

$$\Delta = 3{\cdot}25 - 0{\cdot}3348\ T + 0{\cdot}0039\ T^2.$$

The observations on Gothard springs show a remarkable difference of temperature dependent upon the exposure of the ground to the sun; whilst the surface temperature of sunny ground is expressed by the relation $\theta' = 1{\cdot}32\ (\theta + 0{\cdot}52)$, that of shaded ground finds its expression by $\theta'' = 0{\cdot}97\ (\theta - 0{\cdot}95)$. The mean error of θ, when computed by the formula mentioned above, is $\pm\ 1{\cdot}12^\circ$.

For eliminating the influence of uneven surface and of neighbouring masses on a regular increase of temperature towards the interior, the writer has tried to find out the height above sea of ideal horizontal planes which would correspond to the broken surface above each point of observation. The leading idea was that the temperature t in the centre of a sphere, Fig. 1, must be equal to the average temperature t' on the

Fig 1.

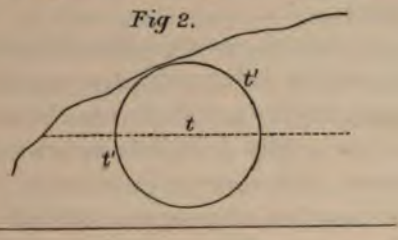


surface of that sphere provided that it be situated below a horizontal plane, that the rock be homogeneous, and possesses the same conductivity in all directions, that the flow of heat has become steady, and that the diameter of the sphere be small in comparison with that of the earth.

If any point of observation in the tunnel be supposed to be the centre of a sphere which touches the uneven surface above without cutting it, and if the average surface temperature of that sphere is found, in most cases it will be seen that it is not equal to t, Fig. 2, and the difference $t - t'$ gives means to calculate the position of the equivalent horizontal plane, the temperature of the ground at the surface being also known. The subsequent observations on temperature along the line

of tunnel permit a computation to be made of the average temperature in one great circle of the sphere; but they are not sufficient for the tempera-

Fig 2.



tures in other sections as far as no suppositions are made with regard to the uniformity of gradients in cross sections. This, and the unreliability of the topographical maps, prevented the writer from beginning a tedious computation of doubtful value, and another method was substituted, which, under the given circumstances, might give quite as good results as the one indicated, but with far less expenditure of time. Cross sections were made at every 100 metres, each cross section having the extent of the diameter of a sphere inscribed from the corresponding tunnel point as centre. The average heights of these cross sections were used for the construction of a longitudinal section. Successive portions of the latter, equal in length to the diameters of the respective inscribed circles, were levelled anew; their average heights should answer to the required heights of horizontal planes which lie above the successive points of observation. A continuous line drawn through the middle points of the successive horizontal planes represents a new profile of the Gothard, extending from Andermatt to Airolo without sensible asperities.*

The observations on rock temperature, etc., made up to 1877, and extending to 4,400 metres from the northern and 4,100 metres from the southern mouth of the tunnel, gave an average increase of temperature towards the interior $\delta = 0{\cdot}02068h$; h being in metres, and δ in degrees Centigrade.

The observations throughout the whole tunnel gave an average increase $\delta = 0{\cdot}02146h$; h being taken from the direct geometrical profile, and θ, the temperature of the ground near the surface, being computed by the new formula mentioned above. The coefficient 0·02146 has an average error

* It was not quite easy to construct reliable cross sections by means of the topographical map to the 1 : 50000 scale with contour lines at every 30 metres. Instead of a straight line of tunnel a broken one has to be drawn on the map, passing through well-known points of the direct profile. The cross sections were taken perpendicularly to the polygonal lines; and finally they had to be raised or lowered till they corresponded with the levelled points of section.

of $\pm$ 0·00130, the average error of temperatures near surface being $\pm$ 1·120°, that of temperatures of rocks in tunnel $\pm$ 0·23°, and of vertical heights $\pm$ 0·83 metres.

The mean height above the sea of the directly surveyed line of section between Göschenen and Airolo is 2,041 metres, and the average temperature near the surface in that line is 3·55°, the mean height of the tunnel (top) is 1,147 metres, and the average depth from surface to tunnel 894 metres. For Alpine mountains of the shape and composition of the St. Gothard, and under the conditions just indicated, the coefficient 0·02146 $\pm$ 0·00130 is available for future use. The average increase of temperature made out on the basis of the ideal planed profile is $\delta = 0{\cdot}02179h''$.

The rock temperatures calculated by this coefficient (and the heights and surface temperatures belonging to this planed profile) differ but a trifle in the middle part of the tunnel (5,000 N. to 6,000 S.) from the observed ones; but beyond these limits there are differences amounting to + 10° (Plain of Andermatt) and — 5° (south side), which cannot be accounted for by topographical reasons, and must be ascribed to the physical properties of the rocks, chemical processes, water, etc.

It was surprising to find that the average gradient for level ground (0·02179) differed so little from the average gradient for broken ground (0·02146), and the writer believes that the reason must be sought in the circumstance that the cooling process in a high isolated mountain, with a large surface surrounded by a cool and always changing medium, works somewhat differently from that in any particular horizon of the earth's crust.

Cordier, Herschel, and Bischof have long ago suggested that the isotherms under mountains should bend upwards. The truth of their opinions can be proved theoretically if the earth is regarded as a cooling body; but the empirical proof was rather incomplete, and briefly based upon some observations of Humboldt and Bonpland, in Mexico and Peru. Indeed observations throughout a whole long Alpine tunnel were necessary to prove the point directly and incontestably. The occasion offered by the Mont Cenis Tunnel passed by unused. Eight observations on rock temperature were made in the southern part of it, but they were made after the boring through, when air passed freely and cooled the rocks. Two-and-a-half years after the piercing of the St. Gothard Tunnel, the rock temperature in its middle part decreased by from 6° to 7°. Nobody knows how much the temperature in the Mont Cenis Tunnel had diminished (at least to a distance of some miles from the mouth) before the observations there

were made, and little more can be inferred from them than that the temperature increased towards the interior. But, even if reliable, these observations would not allow gradients of increase to be plotted, because the surface temperatures on the Mont Cenis are unknown, and because the estimate of Professor Ansted, that the temperature of the ground near the surface was 1° higher than that of the surrounding air, is not correct, for low temperatures, though it may be right enough for the English climate. The writer had special reason to regret the deficiencies of the Mont Cenis observations when the temperature in the St. Gothard Tunnel, 300 metres below the Plain of Andermatt, rose by 22° to 23°, and no experience was available to show what might be expected 1,700 metres below the Kartelhorn. This was a practical question which the writer endeavoured to solve on the basis of the observations which had been made in the St. Gothard Tunnel itself (gradient mentioned above, 0·02068). That the calculation proved a success is of some importance for all future Alpine tunnels.

Two of the empirical relations between increase of temperature (δ) and vertical depth (h) or shortest distance to surface (n) then computed, viz.:—

$$\delta = \sqrt{41{\cdot}6593 - 0{\cdot}1517h + 0{\cdot}000112h^2} + 0{\cdot}01058h + 6{\cdot}454$$

and

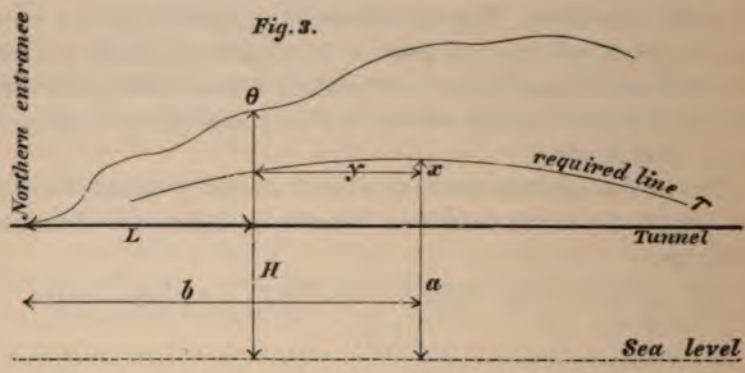
$$\delta = \sqrt{36{\cdot}1682 - 0{\cdot}1278n + 0{\cdot}000103n^2} + 0{\cdot}01016n + 6{\cdot}014$$

lead to imaginary values for $h = 383 \ldots 969$ metres, and $n = 438 \ldots 800$ metres. This means that horizontal isotherms may be met with at certain depths in spite of the undulating surface. This conclusion was verified by a computation of all thermometrical observations made in 1878, between 4,600 and 5,900 metres from the southern mouth. In that portion the absolute height of the surface varies from 2410·5 to 2688·1 metres, the depth of the tunnel from 1250·5 to 1528·4 metres, the temperature near the surface from 1·8° to 0·5° (old formula for θ), the temperature of rock from 30·8 to 28·1°.

If there be between the tunnel and the surface a horizontal isotherm of temperature T and absolute height h; if θ be the temperature near the surface at a point at height H above sea level; if γ be the coefficient of increase of temperature from that point down to the tunnel, then the relation $T + h\gamma = \theta + H\gamma$ is arrived at. By substituting 13 consecutive numerical values for θ, H, γ, as observed from 4,600 to 5,900 metres from the south end, there was found to be $T = 19{\cdot}84 \pm 0{\cdot}4$; $h = 1621{\cdot}3$ metres. It would be easy to calculate in the same manner the height

and temperature of quite a number of local horizontal isotherms in the tunnel section. Instead of this, the writer has tried to make out the position, curvature, and temperature of five continuous lines in five naturally limited portions of the section, viz., 450—1,950; 2,050—3,450; 3,550—6,050; 6,150—11,270; 11,370—14,470 from the northern entrance. The observations 0—400 and 14,500—14,920 were left aside as not being reliable enough.

The continuous lines were assumed to be parabolas, in each of which the parameter (p), the height of the vertex above the sea (a), and the horizontal distance of the vertex from the northern entrance (b), Fig. 3, had to



be determined. Let the sought temperature in such a parabolic isotherm be (T). For any point of the tunnel line belonging to the portion under treatment the distance (L) from the northern entrance is known; further, the temperature θ near the surface vertically above; the absolute height of that surface point (H); and, finally, the coefficient of increase of temperature from it down to the tunnel. A second assumption is that this coefficient is uniform for the whole depth. Then $T = \gamma(H - a + x) + \theta$ and x being $= \frac{y^2}{2p} = \frac{(b - L)^2}{2p}$ that is $\gamma H + \theta = T + \gamma\left(a - \frac{b^2}{2p}\right) + \gamma L \left(\frac{b}{p}\right) - \gamma L^2 \left(\frac{1}{2p}\right)$. Known L, γ, H, θ; unknown T, a, b, p, whence four consecutive numerical values for L, γ, H, θ would be sufficient to determine the constants.

To begin with, it had to be tested whether the whole manner of viewing the subject and reasoning was a right one; hence the writer did not spend much time on arithmetical calculations by the method of least squares, but preferred an approximate method, and introduced in the

formula above the average values of γ, H, θ, L, belonging to the four groups into which the respective portions of the section were divided. The following table gives a summary of all numerical values introduced and of the resulting ones:—

Portions of the Section.	Substituted Average Numerical Values.					Resulting Numerical Values for			
	Between the Stations (reckoned from Northern Entrance.)	L; Middle Distance of these Stations from Northern Entrance.	H; Height of Surface above Sea Level.	θ; Temperature of Ground near Surface.	Co-efficient γ of Increase of Temperature from Surface to Tunnel.	b; Distance of Vertex of the Parabolical Isotherm from Northern Entrance.	a; height of that Vertex above Sea Level.	p; Parameter of the Parabolical Isotherm.	T; Temperature in that Isotherm.
I. 450 to 1950 f.m.e.	450 to 750	600	1492·5	5·13	0·03048	1496·0	1160·3	4477·6	17·99
	850 to 1150	1000	1591·4	4·75	0·02886				
	1250 to 1550	1400	1407·6	5·58	0·04995				
	1650 to 1950	1800	1421·2	5·56	0·04507				
II. 2050 to 3450	2050 to 2350	2200	1432·9	5·55	0·04834	2603·8	1237·6	3125·3	16·26
	2450 to 2750	2600	1433·8	5·60	0·05429				
	2850 to 3050	2950	1436·7	5·62	0·04871				
	3150 to 3450	3300	1440·0	5·65	0·04343				
III. 3550 to 6050	3550 to 4050	3600	1591·6	5·06	0·03248	6024·4	2049·6	6036·1	5·96
	4150 to 4650	4400	1928·6	3·68	0·02368				
	4750 to 5350	5050	2098·7	3·03	0·02332				
	5450 to 6050	5750	2176·1	2·78	0·02407				
IV. 6150 to 11270	6150 to 8270	7208	2627·4	1·02	0·01963	8030·6	1306·5	28284·8	27·19
	8370 to 9370	8870	2436·6	2·01	0·02204				
	9470 to 10770	10120	2506·2	1·86	0·01984				
	10870 to 11270	11070	2247·7	3·06	0·02185				
V. 11370 to 14470	11370 to 11970	11670	2329·0	2·78	0·01998	12081·7	2108·2	3366·1	7·68
	12070 to 12870	12470	2372·9	2·68	0·01739				
	12970 to 13670	13320	2123·4	3·84	0·01584				
	13770 to 14470	14120	1561·4	6·32	0·01939				

It can be assumed that the influences of local superficial protuberances and depressions on regular increase of temperature towards the interior disappear in these local continuous isotherms, which are nevertheless governed by the distribution of the overlying masses in their totality. The question is then arrived at, may there not exist below these local isotherms a continuous isotherm depending on the form of the mountain as a whole?

Let the parameter of that (parabolic) isotherm be (p) the distance of its apex from northern entrance (b), the depth of its apex below sea level (a),

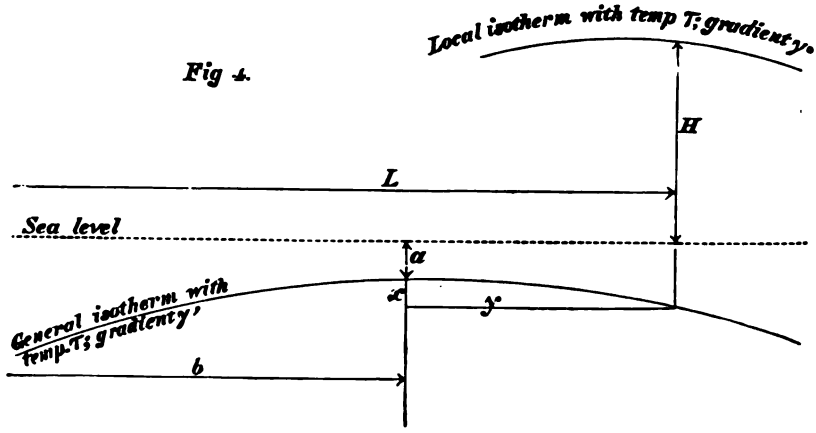


Fig. 4, the temperature in it (T), the coefficient of increase in it (γ'), further let H = (average) height of any of the five local isotherms above sea; L = distance of its middle from northern entrance, τ = temperature and γ° = coefficient of increase in the same; then there will be

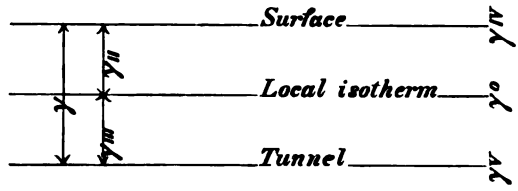
$$T = \tau + \left(\frac{\gamma^\circ + \gamma'}{2}\right)(H + a + x), \text{ and } x \text{ being} = \frac{y^2}{2p} = \frac{(L - b)^2}{2p}$$

$$2\tau + \gamma^\circ H = \left[2T - \gamma'\left(a + \frac{b^2}{2p}\right)\right] - \left[a + \frac{b^2}{2p}\right]\gamma^\circ - [\gamma']H + \left[\frac{b}{p}\right] L(\gamma^\circ + \gamma') - \left[\frac{1}{2p}\right] L^2(\gamma^\circ + \gamma').$$

This equation is still indeterminable; before rendering it fit for solution an endeavour must be made to find γ° or the increase of temperature in the horizon of the five continuous local isotherms. The average absolute height of the surface above each of them; the average temperature of ground near surface; the average height of each isotherm and the tem-

perature in the same; the average height of tunnel (top) and its temperature are known. Consequently the coefficient of increase between the

Fig 5.



surface and the tunnel (γ), Fig. 5, between surface and local isotherm (γ''), and between local isotherm and tunnel (γ''') are also known, there will be

$$\left.\begin{aligned} \gamma &= \frac{\gamma^{v.} + \gamma^{iv.}}{2} \\ \gamma'' &= \frac{\gamma^{o} + \gamma^{iv.}}{2} \\ \gamma''' &= \frac{\gamma^{o} + \gamma^{v.}}{2} \end{aligned}\right\}$$

$\gamma^{v.}$ being coefficient of increase in the horizon of tunnel, γ^{o} in the local continuous isotherm, $\gamma^{iv.}$ near surface whence—

$$\gamma^{o} = \gamma'' + \gamma''' - \gamma.$$
$$\gamma^{iv.} = \gamma'' + \gamma - \gamma'''.$$
$$\gamma^{v.} = \gamma''' + \gamma - \gamma''.$$

The following table contains the numerical values:—

TABLE II.

Portions of the Section.	Average Height of Surface above Sea.	Average Temperature of Ground near Surface.	Average Height of local continuous Isotherm above Sea.	Average Temperature in the same.	Average Height of Top of Tunnel above Sea Level.	Average Temperature of Rock in Tunnel.	Average Co-efficient of Increase from			Co-efficient of Increase near		
							Surface to local continuous Isotherm.	Local continuous Isotherm to Tunnel.	Surface to Tunnel.	Surface.	Local continuous Isotherm.	Top of Tunnel.
			H	τ			γ''	γ'''	γ	γ^{iv}	γ^{o}	γ^{v}
I. 450 to 1950	1478·3	5·26	1129·6	17·99	1122·2	18·40	0·03651	0·05541	0·03690	0·01800	0·05502	0·05580
II. 2050 to 3450	1435·8	5·61	1208·1	16·26	1131·2	20·43	0·04677	0·05423	0·04865	0·04119	0·05235	0·05611
III. 3550 to 6050	1963·3	3·59	1882·2	5·98	1143·1	23·83	0·02947	0·02415	0·02468	0·03000	0·02894	0·01936
IV. 6150 to 11270	2517·9	1·66	1259·7	27·19	1158·3	29·20	0·02029	0·01982	0·02026	0·02073	0·01985	0·01979
V. 11370 to 14470	2098·0	3·90	1894·7	7·68	1154·4	20·76	0·01859	0·01767	0·01787	0·01879	0·01839	0·01695
											0·03491	

The differences here shown between the coefficients of increase at different depths in one and the same portion of section, are not in accordance with the supposition as given above. The final result of this computation cannot be sensibly changed by these differences, but, notwithstanding, they are of some interest, showing that irregularities of the increase of temperature in one and the same artesian well, must not always be ascribed to erroneous observations or accidental convections. Going back to the equation presented higher up, viz. :—

$$2\tau + \gamma^{\circ} \mathrm{H} = \left[2\,\mathrm{T} - \gamma' \left(a + \frac{b^2}{2p}\right)\right] - \left[a + \frac{b^2}{p}\right]\gamma^{\circ} - [\gamma']\,\mathrm{H} + \left[\frac{b}{p}\right]\mathrm{L}\,(\gamma^{\circ} + \gamma') - \left[\frac{1}{2p}\right]\mathrm{L}^2\,(\gamma^{\circ} + \gamma')$$

it will be found that the difference between its two last terms must be small; p being great, $\gamma^{\circ} + \gamma'$ a small fraction, the products b L, and $\frac{\mathrm{L}^2}{2}$ limited. Therefore, as a first approximation, these two terms could be omitted, and a calculation, by help of the remaining ones, of an approximate value for γ', could be made, which could be introduced in the two last terms, and then solve the equation. Instead, the writer has introduced in the two last terms an approximate value for γ', calculated and substituted a more correct value, and then solved the equation. The following numerical values entered :—

TABLE III.

Local continuous Isotherm.	Middle distance of it from Northern Entrance.	Average Height of it above Sea Level.	Average Temperature in it.	Co-efficient of Increase of Temperature in it.	Approximate Value for $\gamma^{\circ} + \gamma'$; viz., $\gamma^{\circ} + 0{\cdot}03491$.
	L	H	τ	γ°	
I. 450 to 1950	1200	1129·6	17·99	0·05502	0·08993
II. 2050 to 3450	2750	1208·1	16·26	0·05235	0·08726
III. 3550 to 6050	4800	1882·2	5·98	0·02894	0·06385
IV. 6150 to 11270	8710	1259·7	27·19	0·01985	0·05476
V. 11370 to 14470	12920	1894·7	7·68	0·01839	0·05330
				0·03491	

The first approximations were:—

$\gamma' = 0{\cdot}03166$
$p = 192469$ metres.
$b = 3347$ „
$a = -330{\cdot}1$ „ (above sea).
$T = 53{\cdot}13°$

Instead of $0{\cdot}03491 = \gamma'$ the value 0·03166 was now substituted in the two last terms of the general equation, so that the figures in the last column of the preceding Table change to 0·08668, 0·08401, 0·06060, 0·05151, 0·05005, whilst all others remain. The five equations then give:—

$\frac{1}{2p} = 0{\cdot}00000275458$; $p = 181516$ metres.

$\frac{b}{p} = 0{\cdot}01826$; $b = 3314{\cdot}5$ metres; $\gamma' = 0{\cdot}03167$.

$a + \frac{b^2}{2p} = -298{\cdot}35$; $a = -328{\cdot}6$ metres (above sea).

$2\,T - \gamma'\left(a + \frac{b^2}{2p}\right) = -9{\cdot}45$; $T = 53{\cdot}235°$. These figures may yet be capable of correction, the whole calculation having been based upon the employment of simple arithmetical averages, and not upon direct substitution of the observed data, the different weight attaching to the single observations having also been neglected. Notwithstanding these imperfections, the writer has good reason to consider the average coefficient of increase 0·03167 to be one of the most reliable hitherto deduced from any observations on underground temperature. It means that near the surface (almost at sea level), and under level ground, the internal temperature increases by 3·167° per 100 metres of vertical depth. Adopting 0·0058 as the mean conductivity of the outer crust of the earth (*vide* Professor Everett, in "Nature," p. 591, October 12, 1882), the flow of heat in a second across a square centimetre would be $0{\cdot}0058 \times 0{\cdot}0003167 = 0{\cdot}000001837$; and the average number of gramme-degrees of heat that escape annually through each square centimetre of a horizontal section of the earth: $0{\cdot}000001837 \times 31500000 = 57{\cdot}9$. Furthermore, it has been shown from the Gothard observations that the isotherms below that mountain swell up, and that the highest continuous isotherm, with a temperature of $53\frac{1}{4}°$, has a radius of curvature of about 181516 metres, whilst the radius of the earth in a latitude of $46\frac{1}{2}°$ is about 6462432 metres. The bow-formed isotherm has its summit, not below the middle of the mountain, but northwards, between the

hottest sections of the tunnel; it cuts the sea level about 650 metres from the southern entrance and its summit is 397 metres above the sea. Knowing the surface temperatures along the line of section, the rock temperatures in the tunnel, the average temperatures of five local continuous isotherms, and the temperature of a principal continuous isotherm, it is easy to interpolate isotherms for whole degrees throughout the whole section. These isotherms follow in upper levels all the inequalities of the surface, whilst below they adjust themselves more and more to the course of the continuous isotherms. They show at a glance that the increase of temperature is more rapid below plains and valleys than below summits, and that these local differences disappear more and more at greater depths. They show irregularities on the south side, which clearly depend on cold springs, they bend down rapidly and then run smoothly inclined below the water-filled section of the mountain. Other local irregularities can be explained by the decomposition of rock; but there is no obvious explanation of the rapid increase in the granite rocks at the northern end of the tunnel (2,000 metres), and it is probably to be attributed to the influence of different thermal qualities of the rocks on the coefficients of increase. For the rest these 200 metres of granite belong to the *massif* of the Finsteraarhorn, and, geologically speaking, they do not share in the composition of the St. Gothard. Perhaps these two *massifs* belong to different geological periods (as supposed for geological reasons long ago). What wonder then if one of them be cooler than the other.

APPENDIX.

Temperature in the St. Gothard Tunnel beneath the Plain of Andermatt.

Distance from Northern Entrance.—Metres.	Mean Distance from Northern Entrance.	Mean Height of Top of Tunnel above Sea Level.	Mean Height of Overlying Ground, above Sea Level.	Vertical Depth from Surface to Top of Tunnel.	Temperature of Ground 1·12 metres below Surface.	Observations on Temperature in the Gallery.							Correction on 11 and 12 to reduce them to 13.		Increase of Temperature.	Gradient, viz., Increase of Temperature on each Metre, Vertical Depth.
						Water.	Face of Gallery—Air.				Air 50 to 200 m. behind Face of Gallery.	Rock.	Correction on 11 (viz., 13-11).	Correction on 12 (viz., 13-12).		
							No Work.	Drilling by Machine.	Hand Work.	Average.						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1800 to 1900	1850	1125·9	1424·0	298·1	5·55	18·34	..	..	..	19·54	19·99	19·43	−0·11	−0·56	3·88	0·04656
1900 to 2000	1950	1126·5	1439·2	312·7	5·50	..	..	18·73	20·99	19·78	19·32	18·94	−0·19	−0·46	13·44	0·04298
2000 to 2100	2050	1127·1	1433·6	306·5	5·53	..	..	..	..	20·65	19·46	19·24	−0·27	−0·36	13·71	0·04473
2100 to 2200	2150	1127·7	1433·6	305·9	5·54	..	..	..	..	20·56	20·46	20·22	−0·34	−0·26	14·68	0·01799
2200 to 2300	2250	1128·2	1431·6	303·4	5·56	..	..	21·13	22·01	21·09	20·89	20·70	−0·36	−0·19	15·14	0·04990
2300 to 2400	2350	1128·8	1432·7	303·9	5·57	..	..	21·47	22·19	21·58	21·09	20·99	−0·38	−0·12	15·42	0·05074
2400 to 2500	2450	1129·4	1433·2	303·8	5·58	..	..	21·77	21·66	21·72	21·94	21·84	−0·40	−0·04	16·26	0·05352
2500 to 2600	2550	1129·9	1433·4	303·5	5·59	..	..	22·82	23·40	23·11	22·71	22·73	−0·42	+0·03	17·14	0·05647
2600 to 2700	2650	1130·5	1434·2	303·7	5·60	21·19	..	20·68	23·17	22·03	21·49	21·59	−0·44	+0·10	15·99	0·05265
2700 to 2800	2750	1131·1	1434·5	303·4	5·61	21·65	22·50	21·65	23·67	22·61	22·08	22·15	−0·41	+0·07	16·54	0·05452
2800 to 2900	2850	1131·7	1435·0	303·3	5·62	21·11	..	..	22·06	..	21·28	21·32	−0·38	+0·04	15·70	0·05176
2900 to 3000	2950	1132·3	1437·3	305·0	5·62	19·59	..	21·13	22·28	21·70	20·45	20·56	−0·35	+0·01	14·94	0·04898
3000 to 3100	3050	1132·9	1437·8	304·9	5·63	18·20	..	18·20	21·00	19·60	19·52	19·47	−0·32	−0·02	13·84	0·04539
3100 to 3200	3150	1133·5	1437·6	304·1	5·64	..	..	..	..	..	19·46	19·40	−0·28	−0·06	13·76	0·04525
3200 to 3300	3250	1134·1	1438·2	304·1	5·65	..	19·28	18·55	20·57	19·47	19·31	19·22	−0·25	−0·09	13·57	0·04462
3300 to 3400	3350	1134·6	1439·2	304·6	5·65	..	..	18·05	20·43	19·24	19·18	19·07	−0·28	−0·10	13·42	0·04406
3400 to 3500	3450	1135·2	1445·0	309·8	5·64	..	..	17·70	19·70	18·70	18·04	17·97	−0·31	−0·12	12·33	0·03980
																0·04823

Cols. 3 and 5.—The depths are reckoned to the top of the tunnel, because the observations were made in the little gallery, which was driven close below or above the top.

Col. 6.—The temperatures of the ground near the surface are calculated by the formula $\theta = 6{\cdot}734 + \theta{\cdot}0001096\ D - \theta{\cdot}004256\ (H - 1{,}100)$; D being

distance from northern mouth (Col. 2), H height of surface above sea level (Col. 4). This formula differs a little from that made out in 1877, because the observations on springs have been continued ever since, and extended to springs in higher levels. The mean error of a single observation is $\pm$ 1·12, the mean error of the mean $\pm$ 0·17. There is a sensible difference between the temperatures of sunny and shady ground. The former (sunny) was found to be $\theta' = 1{\cdot}32\ (\theta + 0{\cdot}52)$; the latter (shade) $\theta'' = 0{\cdot}97\ (\theta - 0{\cdot}95)$. The depth below the surface (1·12 metres), in which θ is assumed to prevail, is deduced from a special series of observations on the temperature of water running through a narrow iron pipe, 500 metres long, imbedded 77 centimetres below the surface, and simultaneous observations on the temperature of the ambient air. There was found for gravel $\sqrt{\frac{\pi c}{k}} = 1{\cdot}77$ (one year and 1 metre), and this constant was made use of to compute the depth of springs on the Gothard, which had been observed all the year round.

Col. 7.—Compare with Col. 13. Underground temperatures observed in water-filled narrow wells can but accidentally agree with rock temperatures, the influence of convection being neglected.

Cols. 8, 9, and 10.—These figures are the averages of all single observations respectively made in the lengths indicated in Col. 1. The single observations are registered in the "Geologische Durschnitte des Gotthard Tunnels" (scale 1 : 200), and in the text to the same, edited by the Swiss Confederation, together with the "Rapports Trimestriels sur la marche de l'Entreprise du Gothard, etc."

Col 11.—These average temperatures of air before the face of the little gallery are computed by the formula:— $\dfrac{\frac{\Sigma\ (\text{Col. } 9)}{n'} + \frac{\Sigma\ (\text{Col. } 10)}{n''}}{2}$; or

$\dfrac{\frac{\Sigma\ (\text{Col. } 8)}{n^{\circ}} + \frac{\Sigma\ (\text{Col. } 9)}{n'} + \frac{\Sigma\ (\text{Col. } 10)}{n''}}{3}$ (n = number of respective single observations).

Col. 12.—On the occasion of the monthly geological surveys of the gallery, that is to say, of the length opened during each preceding month, slow acting thermometers were suspended at all fixed points, the average distance between them being about 10 metres. This series of observations gave very reliable results, showing that the mean temperature of air, 50 to 150 metres behind the face, was rather stationary, and that it

differed but little from the temperature of the rock (Col. 15). The figures of Col. 12 are the averages of all single observations at every 100 metres (registered in the reports mentioned above).

Col. 13.—The figures underlined are direct observations on the temperature of rock, as measured in holes of 1·1 metre in depth, with slow acting, *i.e.*, protected thermometers. Most of these observations were made in the face of the little gallery; none in the finished tunnel; the observations begun this year are not included; some few in the excavations behind, but always in fresh walls.

Cols. 14 and 15 give the differences between the direct observations on rock temperatures and the mean temperatures of air before the face (Col. 11), and behind (Col. 12), always at the same distances from the mouth of the tunnel. The figures between the underlined ones in the same columns are interpolated. By the help of these corrections the temperatures of air have been made fit for completing the series of direct observations on rock temperature (Col. 13, figures between the underlined ones). The weight of the figures in Col. 11 $\pm$ corrections as compared with those in Col. 12 $\pm$ corrections, was found to be 8·1 (in the northern part of the tunnel). For instance 3,450: temperature of air at the face of the gallery 18·70; gives temperature of rock $18{\cdot}70 - 0{\cdot}31 = 18{\cdot}39$; temperature of air behind the face of gallery 18·04; gives temperature of rock $18{\cdot}04 - 0{\cdot}12 = 17{\cdot}92$; average temperature of rock at 3,400 to 3,500 $\frac{8 \times 17{\cdot}92 + 18{\cdot}39}{9} = 17{\cdot}97$.

It has been shown that the temperatures of rock, by direct and indirect observations, as put together in Col. 13, throughout the whole tunnel approach the truth to $\pm$ 0,23°; that the mean error of the difference between the temperature of the ground near the surface and the temperature of rock vertically beneath is 1·14°; and that the mean error of each particular gradient (Col. 17) is $\frac{1{\cdot}161}{h}$; (h = vertical depth). It would be wrong to regard the arithmetical mean of gradients between each 100 metres to be a true average gradient: the values of gradients deduced from observations to great depths being much greater than those of the gradients from shallow observations; hence it is indispensable that the average gradient should be computed by the minimum method. The depths from the Plain of Andermatt down to the tunnel differ so little (298 to 310 metres) that the weights of the successive gradients (Col. 17) may be considered to be the same; of course the simple arithmetical mean of all particular gradients (Col. 17) will suffice in that particular case.

The writer thinks it is not the configuration of surface alone which makes the temperature rise below the Valley of Andermatt from 19° to 23°, and then descend to 18°. There is a well-known local focus of heat (decomposition of rock) below that valley, which seems to exercise a sufficient influence. Slight differences (0·1° or so) between the figures of Col. 13 and the corresponding ones as published in 1877 depend on some new direct observations of rock temperature since made below the Plain of Andermatt, on the introduction of variable corrections (Cols. 14 and 15) instead of an average constant, as was done in 1877, and on the introduction of other values for the temperatures observed before and behind the face of the gallery.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, DECEMBER 8TH, 1883, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

GEORGE BAKER FORSTER, ESQ., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting, and reported the proceedings of the Council.

The following gentlemen were elected, having been previously nominated:—

HONORARY MEMBER—

HERR BRASSERT, Chief Inspector of Mines, Bonn-am-Rhine, Germany.

ASSOCIATE MEMBERS—

Mr. D. FERGUSSON, Harrington Colliery, Cumberland.
Mr. BENJAMIN TYZACK, Preston Road, North Shields.
Mr. FRANK MURRAY STILL, 3, Queen Street, Cheapside, London.
Mr. CHARLES FREDERICK WORMALD, Cement Manufacturer, Cross House, Corbridge.

STUDENTS—

Mr. BENJAMIN MCLAREN, Bedlington.
Mr. WILLIAM HAY, Jun., Nostell Colliery, Wakefield.

The following were nominated for election:—

ASSOCIATE MEMBERS—

MR. LAWRENCE W. ADAMSON, Whitley House, Whitley, Northumberland.
Mr. JACOB WALLAU, Messrs. Black, Hawthorn, & Co., Gateshead.

STUDENT—

Mr. MATTHEW BARRASS, Tudhoe Colliery, Spennymoor.

The SECRETARY read the following paper by Mr. W. F. Hall, "On the Haswell Mechanical Coal-getter: an Invention for Working Coal without the aid of Gunpowder or other Explosives:"—

THE HASWELL MECHANICAL COAL-GETTER: AN INVENTION FOR WORKING COAL WITHOUT THE AID OF GUNPOWDER OR OTHER EXPLOSIVES.

By W. F. HALL.

Coal mining, understood in its restricted sense of working the coal, differs considerably in the methods employed, and the extent to which manual labour, directly applied, must be supplemented by other and more powerful means.

This is true of any one seam in a colliery, and it is much more so from the difference of the coal seams in the same colliery, or of the same coal in different parts of a district; while at the same time each district presents its own problem in the nature and position of the coal to be won. But by far the principal operation in all cases is the breaking down, or it may be the breaking up, of the coal after a space has been made at the top or bottom of the seam for this purpose.

By working the coal in a manner to take the fullest advantage of the natural lines of cleavage the additional aid required is minimized, and in some cases altogether dispensed with; but even in these favourable cases the mine has to be laid out systematically to secure this advantage; and to do so a portion of the coal must be won under circumstances which require extraneous help, as in headways courses, winnings, walls, and crosscuts. But in general not merely the developing stages have to be assisted, but the process throughout calls for the operation of other forces than merely the hewer's unaided strength and skill.

The general use of gunpowder and other explosives in coal mining has, therefore, not arisen so much from choice as from the absence of any other agent so efficient, either chemical or mechanical; and were it not for the serious defects that are developed in its use, probably it would long maintain its position. Unfortunately these defects are too great to be overlooked.

The first charge against it is that it shatters the coal, producing a large percentage of small, and affecting the cohesion of the round to such an extent that it falls to pieces in transit, and is thereby materially reduced in value.

The second is that it vitiates the atmosphere in which the miner has to work. The grains of solid powder when exploded suddenly resolve themselves into a volume of gas that is inimical to human life. If the explosion takes place in the open air, the action of natural laws would soon restore a healthy atmosphere; but as it is, a further burden is thrown upon a complicated and expensive system of ventilation which can ill afford the additional task.

But the most serious charge of all is that it tends to increase the possibility of a colliery explosion. This is the worst form of evil that can overtake a mining engineer; but happily it is rare, when the vast operations that are going on are taken into consideration. Still, every care is required, and it is the interest of all concerned to reduce the risk to the lowest factor.

The tendency to regard gunpowder as an element of danger in a coal mine, has of late increased to such an extent as to cause those interested to look with some concern upon the future. The number of restrictions and regulations which official authority has imposed upon its use, and is still imposing, mark that tendency very clearly; and it is felt that if this is carried much further, large areas of coal will be rendered unprofitable to work, unless some efficient substitute is found.

On these grounds the writer asks the patient consideration of an invention which he hopes may prove of service to the coal mining industry, by largely, if not entirely, taking the place of gunpowder in working coal

The Haswell Mechanical Coal-Getter, shown in Plate I., figs. 1, 2, 3, 4, and 5, is a combination of screw, lever, and wedge. *e e*, figs. 3 and 4, are two expanding blocks; *f* is a wedge to expand them; *g* is a bar for thrusting in the wedge; *h h* are straps uniting each end of the machine together, which can be disconnected at the coupling box *i*, fig. 2; *k k k k* are four pairs of links; the front pair are connected by a pin *p* to the straps *h h;* and the other pair next the face of the coal are connected to a movable block or crosshead *l*, thrusting against the bar *g*, in contact with the wedge *f*. The screw *m*, fig. 1, works in a nut at *n*, and in a loose collar at *o*, and when made to turn by a ratchet brace attached to the square end *m*, it brings the levers *k* together and forces the rod *g* and wedge *f* into the blocks *e e*.

From the above description of the machine it will be seen that the bursting action is accomplished by a wedge, as in the old "stub and feather," to which it has been compared; and in this, as in the old instrument, the initial power which drives the wedge is manual force. But beyond these two simple facts all resemblance ceases; for while in the one case

the man's power was measured by the amount of force he could deliver in the blow of a mallet, in this case his force is immensely multiplied by a special combination of mechanical forces. Further, the bursting action of the wedge in the old instrument commenced at the face of the jud where it was least required. This increased its inefficiency by breaking away the front of the coal, which ought to have remained to assist in bringing down the jud in a body to the back of the kirving by its weight and leverage. In the case of this machine, the bursting force is placed at the very point where of all others it can be most effective, and where it commands every advantage that can be gained in the operation, without a single drawback in regard to position.

Appended to this paper is an account of a number of experiments made in the Low Main Seam at Haswell Colliery in the presence of various mining engineers. These accounts are taken from the notes made by one of the party at the time, and in most cases have been compiled by the person who took the notes. It is further to be observed that these experiments were not made specially in carefully selected and prepared places, but were made while following the daily routine of work done by the machine.

The Low Main Seam at Haswell Colliery is a hard steam coal from 3 feet 4 inches to 3 feet 6 inches thick, and is found at about 135 fathoms below the surface. The record gives a list of twelve juds taken down in long-wall working, and the length of juds range from 21 to 33 feet, with a kirving of from 3 feet 4 inches to 3 feet 6 inches, giving an average on the twelve juds of 26 feet by 3 feet 5 inches. In each case, as is usual, the jud has one loose end.

The mode of operation in ordinary cases is to bore a hole about 4 inches from the roof, and at from 3 to 5 feet from the fast side, after the coal has been kirved by the hewer. This gives a length of above 20 feet of coal, along which the bursting force must travel before it reaches the loose end. The straps are first put into the hole, followed by the blocks and the wedge, each of which are firmly driven home by the wedge bar before it is put into its position against the wedge. The machine is then linked upon the straps, and a few turns of the screw secures the whole firmly in position. All this is the work of a few minutes. The sprags are then looked after, if not already in their place; for on the judicious manipulation of sprags much of the success depends. The duty of the sprags is to assist the motion of the force along the jud from the machine to the loose end, as the action of the machine at a distance of above 20 feet depends on the cohesion of the coal being maintained throughout the jud. This explains the reason why in one case (No. 5 experiment) two holes were put in,

the unity of the coal having been broken up by a hitch. Although the time is given in each case—and though a typical case will not last more than twelve minutes (see experiment No. 9)—yet the work is not a question of speed, for it is well understood by practical miners that time must be given for the coal to work. After seeing that the sprags are all right, the workman places himself at the ratchet and alternately screws and pauses as in his judgment the case requires. After the first cracking sounds are heard the burden of screwing is lightened; and when it has reached the loose end, the "wedger" knows that his work is done. He then knocks out the sprags, when the jud comes away in a mass, breaking into large pieces as it falls.

Wide boards have also been regularly worked with the machine in the Low Main Seam at Haswell Colliery; and Nos. 8 and 10 experiments may be taken as fairly representing the results. The boards are 16 and 18 feet wide; and are kirved in 3 feet 6 inches and 3 feet 4 inches deep respectively. A hole is bored at the top of the jud about 2 feet from each fast side, and sprags are used. A machine is put into each hole, and if in the judgment of the operator the jud is more likely to work from one side than the other, that side is pushed away first; then the machines are worked alternately until the coal is brought down. In these two cases the time was twenty-seven and twenty-nine minutes respectively.

Experiment No. 16 shows a headways place taken down. It was 18 feet wide and kirved in 3 feet 6 inches. Three holes were bored in the jud—one at each fast side and one in the middle. The machines were put into the right hand and middle, or Nos. 2 and 3 holes. After twenty-seven and a half minutes' operation the notes say:—"The whole of the coal from right-hand nook up to No. 1 hole fell down, and the remainder to left nook loosened, so that it was easily pulled down."

Since then most of the headways places have been worked similarly to boards, that is, with two holes only.

In some collieries it is more convenient and economical to kirve at the top or middle of the seam, and break up the coal by explosives. In view of this, experiments were tried in the Low Main and Main Coal Seams at Haswell Colliery to raise the jud instead of breaking it down. Nos. 17 and 18 experiments refer to this.

Experiment No. 17, Low Main Seam.—The coal was kirved at the top of the seam, and a hole drilled for the machine in the bottom, at about the middle of the jud. The whole of the coal was lifted square off by the back of the jud tapering away a little at the fast side. Length of jud 18 feet.

Experiment No. 18, Main Coal Seam.—In this experiment the kirving

was in a 1 foot 6 inch ramble, which was kirved 3 feet in. The holes for the machine were drilled at the bottom. The first two holes were put in next the loose side, and two machines were worked simultaneously, when the coal was lifted to within three yards of the fast side. Another hole was then put in one yard from the fast side, which lifted the remainder of the jud. The coal next the ramble is a little tender, and in ordinary working yields too much small; but in this experiment it was found to come away in large pieces without any waste. Total length of jud 30 feet.

The machine is in regular use at Ryhope Colliery taking down top canches, or lifting bottom ones. No. 19 is one of the earliest of the experiments made there in stone canches. The trial was in grey metal with iron girdles, to make wagonway height. The canch was 24 inches thick by 8 feet 6 inches wide. A plank was fixed, by two props, underneath the line of hole before wedging commenced. The hole was bored 3 feet 2 inches deep. After forcing the wedge up to its full extent the props were withdrawn, when a large quantity of the stone came down, the remainder hanging ready for pinching down. This cleared a space 6 feet in length by 8 feet in width. Time occupied in boring and wedging seventy-five minutes.

Experiment No. 20 shows similar good effects in bottom canches.

The same method of work will apply in long-wall gateways.

The question of cost of operation depends largely on the nature of the coal and the thickness of the seam, but it will be found to compare favourably with gunpowder, the cheapest of all present agencies. In a colliery where the machines are put into regular and systematic use, it will be found advisable to divide the work between the hewer and the man with the machine, who may be called the "wedger," as follows:—

The hewer will prepare the jud by kirving it, and afterwards fill the coals. The "wedger" will follow round as the juds are prepared, drill his holes, and wedge down the coal. In this way a man becomes familiar with the machine, acquires the "knack" of using it to purpose, and obtains the best results. In a thin seam like the Low Main at Haswell a "wedger" will bring down above 40 tons per shift. In a thicker seam the quantity would be proportionately more, and the cost, therefore, less. By dividing the "wedger's" wage by the coal produced, the cost per ton is arrived at. This must be compared with the value of the time occupied by the hewer in drilling his holes, and the gunpowder he uses.

The condition of the coal obtained by this process is all that can be

desired. Unlike the action of gunpowder, which spends its force in a sudden shock, in this case the bursting power is applied gradually, and to the extent desired, so that the main lines of cleavage are alone affected, and the coal is found in large, square and unshattered blocks. Not merely is there a less percentage of small, but the natural cohesion of the round is in no way destroyed, so that it does not fall to pieces in transit as in the case of coal brought down by explosives.

The ventilation of the mine is also in no way affected by this mode of getting coal. This is the second point in which it contrasts very favourably with gunpowder and other explosives, the effects of which the writer has already noticed.

Other points of contrast readily occur, such as simplicity and safety of application, freedom from anxiety as to storage, absence of injury to roof, etc.; but the one point which outweighs all others is its perfect immunity from danger. Without venturing to express an opinion as to the cause of colliery explosions, as there are other sources of danger besides gunpowder, yet the absence of explosives in coal mines would no doubt be regarded with satisfaction throughout the entire mining community; and if to attain this, and the kindred advantage of an unaffected atmosphere, some sacrifice was called for, the objects to be gained would justify it; but the trials already made by this machine leave the hope that these will be attained without such sacrifice, and an additional benefit secured of having a more marketable coal to dispose of.

The writer may be allowed to add that this is in no sense a difficult or complicated machine to deal with; nor one that requires what may be called "skilled hands" to manage it. Ordinary intelligence and powers of observation, and a knowledge of the mode in which coal works, which is familiar to every miner, combined with ordinary care, is all that is required in its use.

To illustrate Mr. W. F. Hall's paper "On the Haswell Mechanical Coal-getter."

FIG. 1.

Part of the Machine which is Outside the Coal when it is being wedged down.

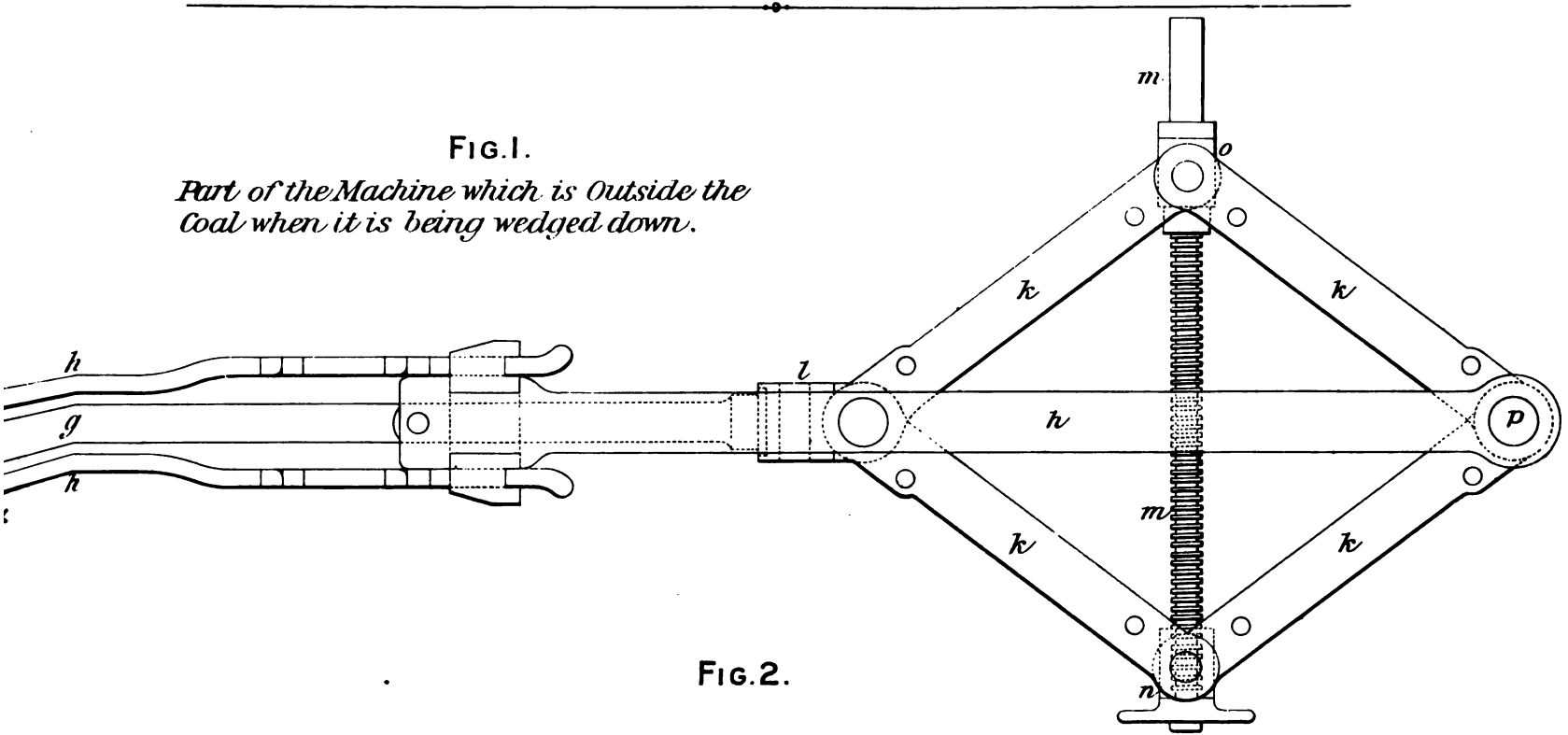
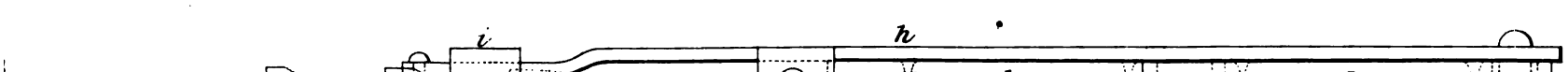


FIG. 2.



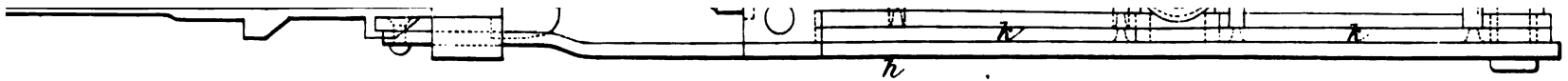


FIG. 3.
Part of the Machine which is Inside the Hole Bored in the Coal when it is being wedged down.

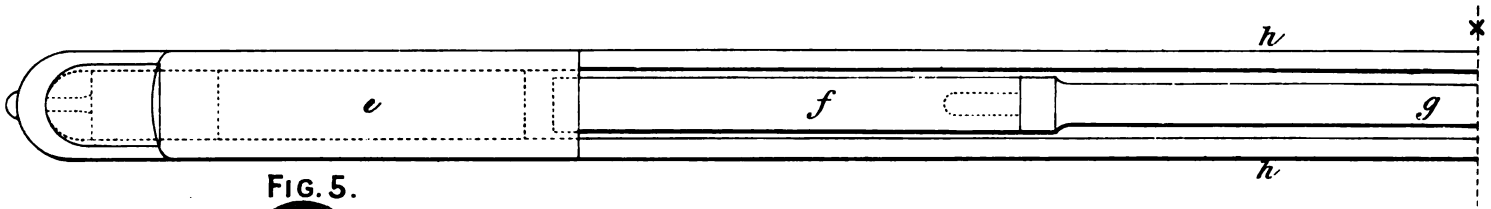
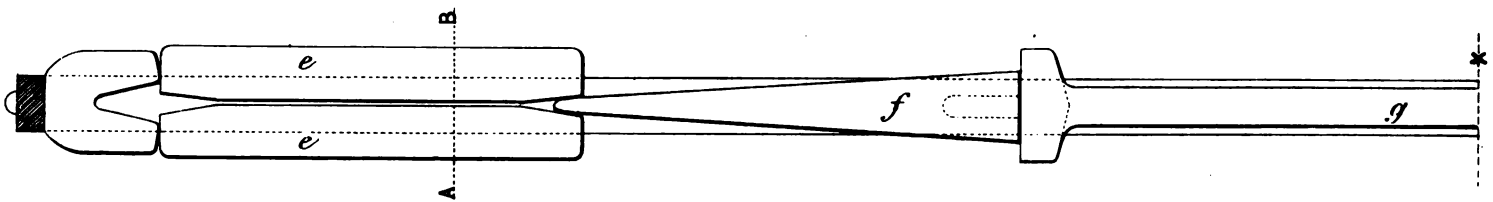


FIG. 5.

SECTION THRO' A.B.

FIG. 4.



Proceedings No. E1 of M&ME 1883-84

FIG'S 1&2 JOIN 3&4 AT X

Amd. Reid. Newcastle.

HASWELL COLLIERY.

Summary of the Experiments made with the Haswell Mechanical Coal-getter, in the Low Main Seam, October, 1883.

Experiment No.	Description of Place Worked.	Length of Face.	Holes 3½ in. Diameter. No.	Holes 3½ in. Diameter. Depth.	Depth of Kirving.	Coal brought down.	Time occupied in Wedging.	Remarks.
		Ft.		Ft. In.	Ft. In.	Tons.	Min.	
1	Long-wall jud, loose at one end	33	1	3 8	3 6	10½	21	.....
2	Do. do. ...	27½	1	3 8	3 6	8½	22	.....
3	Do. do. ...	20½	1	3 6	3 4	6½	6½	.....
4	Do. do. ...	21	1	3 8	3 6	6¾	16½	.....
5	Do. do. ...	28½	2	3 8	3 6	9¼	10	A hitch in this place, causing two holes to be made.
6	Do. do. ...	27	1	3 8	3 6	8¼	17	.....
7	Do. do. ...	24	1	3 8	3 6	8¼	44	The seam rises 1 in 24 from the hole, preventing the coal coming down freely.
8	Board, fast at each side ...	16	2	3 8	3 6	5	27	.....
9	Long-wall jud, loose at one end	27	1	3 6	3 4	8	12	.....
10	Board, fast at both ends ...	18	2	3 8	3 4	5¾	29	.....
11	Long-wall jud, loose at one end	21¾	1	3 6	3 4	6½	15½	.....
12	Do. do. ...	24	1	3 6	3 4	7¼	25	.....
13	Do. do. ...	24¾	1	3 9	3 6	7½	11½	.....
14	Do. do. ...	27¾	1	3 9	3 6	8½	21¾	.....
15	Board, fast at each side ...	16½	2	3 9	3 6	5	46	.....
16	Headways way, or end on do.	18	3	3 9	3 6	6	27½	.....
17	Long-wall jud, loose at one end	18	1	3 3	3 6	...	...	Kirved in top of seam, hole in bottom. The whole of the coal was lifted to back of jud.
	In Main Coal—							
18	Long-wall jud, loose at one end	30	3	3 2	3 0	...	...	Kirved in 18 in of ramble, above the seam. Three holes at bottom, lifting all the coal to back of jud.
19	Ryhope Colliery experiments in stone; taking down top canch for wagonway height.							
20	Do. experiments in seggar clay stone; taking up bottom canch for wagonway height.							

EXPERIMENT No. 1.

Low Main Seam, Haswell Colliery.

Fig. 1.

Long-wall Jud, loose at right end. One machine hole.

	Ft.	In.		Ft.	In.
Height of seam	3	4	Height of kirving in front... ...	1	3
Length of face	33	0	Depth of coal brought down at fast end	3	4
Distance of hole from fast end ...	3	0	Do. at loose end	3	6
Depth of hole	3	8			
Depth of kirving	3	6			

Time.

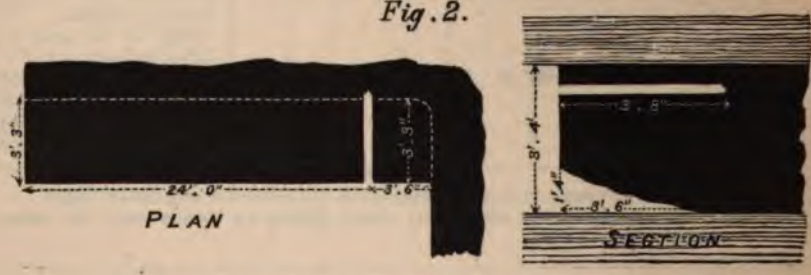
	p.m.		p.m.
Commenced to set machine ...	1 19	Machine lighter to work (1 man screwing)	1 27
Commenced to screw	1 21	Stopped to advance machine second time	1 33
Stopped to advance machine ...	1 23½	Recommenced screwing	1 34½
Recommenced screwing	1 24¼	Coal all down	1 40
Pressure heavy to work (2 men screwing) coal working	1 25		

Coal brought down, 10½ tons; time occupied, 21 minutes.

EXPERIMENT No. 2.

Low Main Seam, Haswell Colliery.

Fig. 2.



Long-wall Jud, loose at left end. One machine hole.

	Ft.	In.		Ft.	In.
Height of seam	3	4	Height of kirving in front... ...	1	4
Length of face	27	6	Depth of coal brought down at fast end	3	3
Distance of hole from fast end ...	3	6	Do. at loose end	3	3
Depth of hole	3	8			
Depth of kirving	3	6			

EXPERIMENT No. 2.—Continued.

Time.

	p.m.		p.m.
Commenced to screw	1 54	Coal working	2 5
Stopped to advance machine ...	1 56	Ceased screwing	2 7
Recommenced screwing; coal working	1 57	Knocked chocks out	2 8
Coal working	1 58	Stopped to advance machine ...	2 10
Coal working	2 0	Recommenced screwing	2 12
Stopped to advance machine second time	2 3	Ceased screwing; coal all given; prised the coal down with a plate	2 13
Recommenced screwing	2 4	Coal all down	2 16

Coal brought down, 8½ tons; time occupied, 22 minutes.

EXPERIMENT No. 3. (See Fig 1.)

Low Main Seam, Haswell Colliery.

Long-wall Jud, loose at right end. One machine hole.

	Ft.	In.		Ft.	In.
Height of seam	3	4	Height of kirving in front... ...	1	4
Length of face	20	6	Depth of coal brought down at fast end	3	4
Distance of hole from fast end ...	4	0	Do. at loose end	3	4
Depth of hole	3	6			
Depth of kirving	3	4			

Time.

	p.m.		p.m.
Commenced to screw	2 24	Coal working heavy	2 30
Stopped to advance machine ...	2 28	Coal all down	2 30½
Recommenced screwing; coal beginning to work	2 29		

Coal brought down, 6½ tons; time occupied, 6½ minutes.

EXPERIMENT No. 4. (See Fig. 2.)

Low Main Seam, Haswell Colliery.

Long-wall Jud, loose at left end. One machine hole.

	Ft.	In.		Ft.	In.
Height of seam	3	4	Height of kirving in front... ...	1	4
Length of face	21	0	Depth of coal brought down at fast end	3	6
Distance of hole from fast end ...	3	0	Do. at loose end	3	6
Depth of hole	3	8			
Depth of kirving	3	6			

Time.

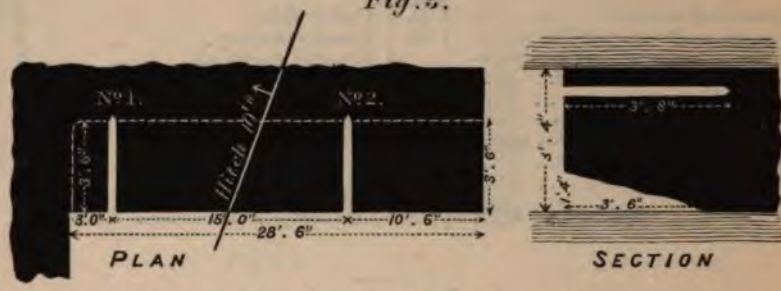
	p.m.		p.m.
Arrived in place	2 37	Stopped to advance machine second time	2 49
Commenced to screw	2 41	Recommenced screwing	2 52½
Stopped to advance machine ...	2 43	Coal working	2 53
Recommenced screwing	2 45	Coal all down	2 53½
Coal working	2 46		

Coal brought down, 6¾ tons; time occupied, 16½ minutes.

EXPERIMENT No. 5.

Low Main Seam, Haswell Colliery.

Fig. 2.



Long-wall Jud, loose at right end. Two machine holes.

	Ft.	In.		Ft.	In.
Height of seam	3	4	Depth of kirving	3	6
Length of face	28	6	Height of kirving in front... ...	1	4
Distance of hole No. 1 from fast end	3	0	Depth of coal brought down at fast end	3	6
Do. do. No. 2 „ loose end	10	6	Do. at loose end	3	6
Depth of holes	3	8			

Time.

No. 1 Hole.	p.m.		*No. 2 Hole.*	p.m.	
Commenced to screw	12	42	Commenced to screw	12	45
Coal working	12	44	Coal set off	12	46
Coal set off	12	46	Stopped to advance machine ...	12	47
Stopped to advance machine ...	12	47½	Recommenced screwing	12	49
Recommenced screwing	12	49	Standing waiting for No. 1 machine	12	50
Working slow, coal working freely	12	50½	Recommenced screwing, coal working freely	12	51½
Coal down	12	52	Coal all down	12	52
Machine on to tram and sent away	12	57			

Coal brought down, 9¼ tons; time occupied ... ... 10 minutes.
Time occupied taking down and removing machine ... ... 5 „

Total ... ... 15 „

Five sprags used.

N.B.—The reason two holes were put in this place was the step or hitch shown in the Figure.

EXPERIMENT No. 6. (See Fig. 1.)

Low Main Seam, Haswell Colliery.

Long-wall Jud, loose at right end. One machine hole.

	Ft.	In.		Ft.	In.
Height of seam	3	4	Depth of coal brought down at fast end	3	10
Length of face	27	0	Do. to right of hole	3	4
Distance of hole from fast end ...	3	6	Do. at centre of face	3	6
Depth of hole	3	8	Do. at loose end	3	3
Depth of kirving	3	6			
Height of kirving in front... ...	1	4			

EXPERIMENT No. 6.—Continued.

Time.

	p.m.		p.m.
Arrived in place	1 0	Sprags removed, in meantime machine standing	1 15
Commenced to screw	1 3	Recommenced screwing, and coal down	1 17
Coal working	1 4	Left place	1 20
Stopped to advance machine ...	1 9		
Recommenced screwing	1 10		
Coal working freely	1 11½		

Coal brought down, 8¼ tons.

Time occupied removing from last place	3	minutes.
Do. in getting coal down	17	„
Do. in taking down and removing machine ...	3	„
Total	23	„

Six sprags used.

EXPERIMENT No. 7. (See Fig. 2.)

Low Main Seam, Haswell Colliery.

Long-wall Jud, loose at left end. One machine hole.

	Ft.	In.		Ft.	In.
Height of seam	3	4	Height of kirving in front... ...	1	5
Length of face	24	0	Depth of coal brought down at fast end	3	6
Distance of hole from fast end ...	3	6	Do. at loose end	3	6
Depth of hole	3	8			
Depth of kirving	3	6			

Time.

	p.m.		p.m.
Arrived in place	1 23	Machine full up	1 47
Commenced to screw	1 26	Machine out; coal still up, but broken and ready to come down (some time lost in seeking a common wedge)	1 50
Coal working	1 28	Commenced to drive in common wedge	2 0
Stopped to advance machine ...	1 32½	Coal all down	2 7
Recommenced screwing	1 34		
Stopped to advance machine second time	1 40		
Recommenced screwing	1 41½		
Chocks drawn	1 46		

Coal brought down, 8¼ tons.

Time occupied in removing from last place, 142 yards ...	3	minutes.
Do. getting coal down	44	„
Total	47	„

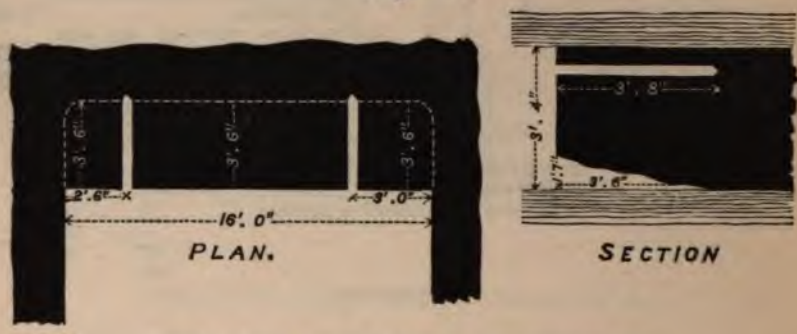
Four sprags used.

N.B.—In consequence of seam rising at 1 in 24 from machine to loose end, the coal did not work freely.

EXPERIMENT No. 8.

LOW MAIN SEAM, HASWELL COLLIERY.

Fig. 4.



Board or Drift, fast at both ends. Two machine holes.

	Ft.	In.		Ft.	In.
Height of seam	3	4	Height of kirving in front... ...	1	7
Length of face	16	0	Depth of coal brought down at right side	3	6
Distance of hole from right side ...	3	0	Do. at centre	3	6
Do. left side ...	2	6	Do. at left side	3	6
Depth of holes	3	8			
Depth of kirving	3	6			

TIME.

No. 1 Hole.	p.m.	*No. 2 Hole.*	p.m.
Arrived in place	2 16	Commenced screwing	2 33
Commenced to screw	2 17	Coal working	2 34
Stopped to advance machine; coal broken	2 21	Stopped to advance machine ...	2 35
Recommenced screwing	2 23	Recommenced screwing	2 37½
Stopped to advance machine second time	2 29	Coal down	2 43
Recommenced screwing	2 30½	One sprag used.	
Machine up; coal given all across face	2 32½		

Coal brought down, 5 tons; time occupied, 27 minutes.

EXPERIMENT No. 9. (See Fig. 1.)

LOW MAIN SEAM, HASWELL COLLIERY.

Long-wall Jud, loose at right end. One machine hole.

	Ft.	In.		Ft.	In.
Height of seam	3	4	Height of kirving in front... ...	1	4
Length of face	27	0	Depth of coal brought down at fast end	3	6
Distance of hole from fast end ...	3	0	Do. at loose end	3	6
Depth of hole	3	6			
Depth of kirving	3	4			

TIME.

	p.m.		p.m.
Commenced to screw	1 7	Stopped to advance machine second time	1 15
Coal commencing to work	1 9	Recommenced to screw	1 15½
Stopped to advance machine ...	1 9	Coal down	1 19
Recommenced to screw	1 10		

Coal brought down, 8 tons; time occupied, 12 minutes.
Five sprags used.

EXPERIMENT No. 10. (See Fig. 4.)

Low Main Seam, Haswell Colliery.

Board, fast at both ends. Two machine holes.

	Ft.	In.		Ft.	In.
Height of seam	3	4	Height of kirving in front... ...	1	5
Length of face	18	0	Depth of coal brought down at right side	3	4
Distance of hole No. 1 from left side	2	0	Do. at left side	3	4
Do. No. 2 from right side	2	0	Do. at centre	3	4
Depth of holes	3	8			
Depth of kirving	3	4			

Time.

No. 1 Hole.	p.m.		*No. 2 Hole.*	p.m.	
Commenced to screw	1	47	Commenced to screw	1	56
Coal commenced to work	1	48½	Stopped to advance machine ...	2	0
Stopped to put second machine into No. 2 hole	1	52	Recommenced screwing	2	2
Advanced machine	2	1	Stopped to advance machine second time	2	7
Recommenced screwing	2	2½	Recommenced screwing	2	10
Stopped to advance machine second time	2	10	Coal down	2	16
Recommenced screwing	2	13			
Coal down	2	16			

Coal brought down, 5¾ tons; time occupied, 29 minutes.

EXPERIMENT No. 11. (See Fig. 2.)

Low Main Seam, Haswell Colliery.

Long-wall Jud, loose at left end. One machine hole.

	Ft.	In.		Ft.	In.
Height of seam	3	4	Height of kirving in front... ...	1	6
Length of face	21	9	Depth of coal brought down at fast end	3	4
Distance of hole from fast end ...	3	6	Do. at loose end	3	4
Depth of hole	3	6			
Depth of kirving	3	4			

Machine in hole.

Time.

	p.m.			p.m.	
Commenced to screw	12	23	Recommenced screwing	12	30½
Coal working	12	25	Stopped screwing	12	38
Coal set off	12	28	Coal all down	12	38½
Stopped to advance machine ...	12	29			

Coal brought down, 6½ tons; time occupied 15½ minutes.

EXPERIMENT No. 12. (See Fig. 1.)

Low Main Seam, Haswell Colliery.

Long-wall Jud, loose at right end. One machine hole.

	Ft.	In.		Ft.	In.
Height of seam	3	5	Height of kirving in front... ...	1	5
Length of face	24	0	Depth of coal brought down at fast end	3	4
Distance of hole from fast end ...	3	6	Do. at loose end	2	7
Depth of hole	3	6	Do. at centre	3	4
Depth of kirving	3	4			

EXPERIMENT No. 12.—Continued.

Time.

	p.m.		p.m.
Commenced to set machine ...	12 51	Stopped to advance machine second time	1 13
Commenced to screw	12 55	Recommenced to screw	1 16
Coal working	12 57	Stopped screwing	1 19¾
Stopped to advance machine ...	1 3½	Coal all down	1 20
Recommenced to screw	1 6½		
Coal set off	1 8½		

Coal brought down, 7¼ tons; time occupied, 25 minutes.

N.B.—In explanation of the long time occupied, it may be stated that at the loose end there was a "roll" in the roof, making a very fast top; and when the coal was got down there was found in the fast nook a cross "back" which held the coal.

EXPERIMENT No. 13. (See Fig. 1.)

Low Main Seam, Haswell Colliery.

Long-wall Jud, loose at right end. One machine hole.

	Ft.	In.		Ft.	In.
Height of seam	3	4	Height of kirving in front... ...	1	6
Length of face	24	9	Depth of coal brought down at fast end	3	6
Distance of hole from fast end ...	5	0	Do. at loose end	3	6
Depth of hole	3	9			
Depth of kirving	3	6			

Time.

	p.m.		p.m.
Commenced to set machine ...	1 26	Stopped to advance machine second time	1 35½
Commenced to screw	1 27½	Recommenced to screw	1 37½
Stopped to advance machine ...	1 29½	Coal all down	1 38½
Recommenced to screw	1 31		

Coal brought down, 7½ tons; time occupied, 11½ minutes.

EXPERIMENT No. 14. (See Fig 2.)

Low Main Seam, Haswell Colliery.

Long-wall Jud, loose at left end. One machine hole.

	Ft.	In.		Ft.	In.
Height of seam	3	6	Height of kirving in front... ...	1	6
Length of face	27	9	Depth of coal brought down at fast end	3	6
Distance of hole from fast end ...	3	6	Do. at loose end	3	6
Depth of hole	3	9			
Depth of kirving	3	6			

Time.

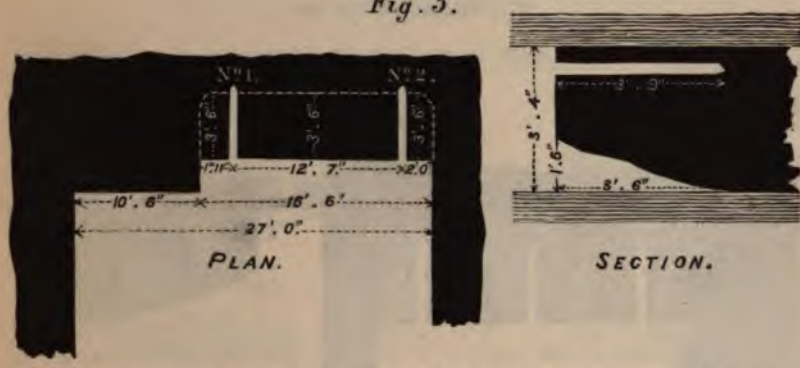
	p.m.		p.m.
Machine arrived in place	1 54	Back of kirving fell away	2 11½
Commenced to erect machine ...	1 55½	Stopped to advance machine, second time	2 13
Commenced to screw	1 57	Recommenced to screw	2 15¼
Coal working	1 58½	Stopped screwing to draw sprags ...	2 17½
Stopped to advance machine ...	2 2½	Coal all down	2 18¼
Recommenced to screw	2 5		

Coal brought down, 8½ tons; time occupied, 21¾ minutes.

EXPERIMENT No. 15.

LOW MAIN SEAM, HASWELL COLLIERY.

Fig. 5.



Board, fast on each side, at right angles to cleat of coal. Two machine holes.

	Ft.	In.
Height of seam	3	4
Length of face	16	6
Distance of No. 1 hole from left side	1	11
Do. No. 2 do. right side	2	0
Depth of hole	3	9
Depth of kirving	3	6

	Ft.	In.
Height of kirving in front... ...	1	6
Depth of coal brought down at left fast side	3	6
Do. right fast side	3	6
Do. centre	3	6

TIME.

	p.m.
Two machines arrived in place ...	2 30
Commenced to erect machine in No. 1 hole (No. 1 machine)	2 35
Commenced to erect machine in No. 2 hole (No. 2 machine)	2 38
Commenced to screw No. 1 ...	2 41
Screwing gently	2 44
Coal singing	2 45
Stopped No. 1 and started screwing No. 2	2 46
Screwing gently	2 48
Stopped No. 2 and started No. 1 ...	2 49
Coal still singing	2 51
Stopped No. 1 to advance machine...	2 51½
Recommenced to screw No. 1 ...	2 53
Stopped No. 1 and started No. 2 ...	2 54
Do. No. 2 do. No. 1 ...	2 57½
Screwing both machines	2 58½
Stopped No. 2 to advance machine...	3 0½
Stopped No. 1 to advance machine second time	3 1¼
Recommenced to screw No. 2 ...	3 3¾
Both machines standing	3 4½
Screwing No. 1	3 6
Coal working	3 7

	p.m.
Stopped No. 1, started No. 2 ...	3 8
Do. No. 2, do. No. 1 ...	3 8¾
Both machines screwing	3 9¼
Do. stopped	3 9½
Do. screwing	3 10
Do. stopped	3 10½
Do. screwing	3 12
Stopped No. 1, screwing No. 2 ...	3 13½
Both machines screwing	3 14½
Stopped No. 2 to advance machine second time	3 14½
Both standing, coal falling off in middle	3 15
Screwing with No. 1	3 16
Started No. 2	3 17
Stopped No. 1 to advance machine third time...	3 18
Started No. 1, still screwing with No. 2	3 20½
Stopped No. 2	3 23
Started No. 2, both machines screwing	3 24
Stopped No. 1	3 25
No. 2 still screwing...	3 26
Stopped No. 2	3 27

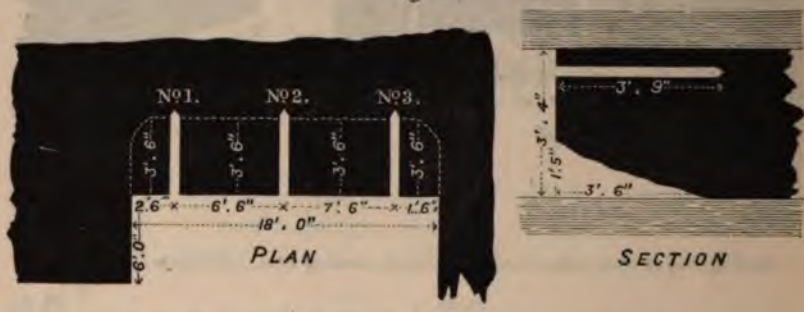
Coal, 5 tons. Time occupied in screwing both machines, 46 minutes.

NOTE.—The coal was not brought down, but it was broken along the whole line of kirved face, and was afterwards easily pulled down with pick.

EXPERIMENT No. 16.

LOW MAIN SEAM, HASWELL COLLIERY.

Fig. 6



Place, fast at each side, was going Headways or "End on." Three machine holes.

	Ft.	In.		Ft.	In.
Height of seam	3	4	Depth of kirving	3	6
Length of face	18	0	Height of kirving in front... ...	1	5
Distance of No. 1 hole from left side	2	6	Depth of coal brought down at left fast side	3	6
Do. No. 2 do. right side	1	6	Do. right fast side	3	6
Do. No. 3 do. both sides	9	0	Do. centre	3	6
Depth of hole	3	9			

Machines brought from last place and fixed in Nos. 2 and 3 holes, so that in this experiment the machines are alluded to as Nos. 2 and 3.

TIME.

	p.m.		p.m.
Commenced to screw No. 2 ...	3 51	Stopped No. 3 to advance machine second time	4 10
Do. No. 3 ...	3 53	Stopped No. 2	4 10
Machines screwed alternately, man at each.		Restarted No. 3	4 14
Coal working	4 0	Restarted No. 2, both machines being screwed	4 17
Stopped No. 2 to advance machine	4 0	Stopped machines to draw sprags ...	4 17½
Stopped No. 3 to advance machine	4 1	Part of face of coal fell away ...	4 18
Recommenced to screw No. 2 ...	4 3	The whole of the coal from right hand nook up to No. 1 hole fell down, and the remainder to left nook loosened, so that it was easily pulled down	4 18½
Stopped No. 2 until No. 3 was ready	4 3½		
Recommenced No. 3, screwing it and No. 2 alternately	4 5		
Both being screwed	4 6½		

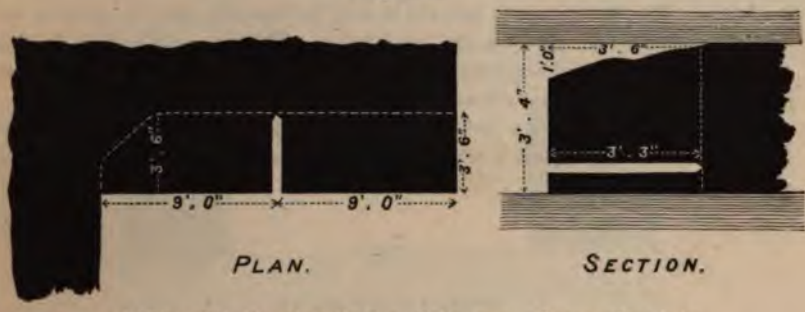
Coal brought down, 6 tons; time occupied, 27½ minutes.

Considering that this was an "end on" or headways place, and fast at both sides, it must be considered a very successful experiment.

EXPERIMENT No. 17.

LOW MAIN SEAM, HASWELL COLLIERY.

Fig. 7.



Lifting Jud, kirved at the top of the seam. One machine hole.

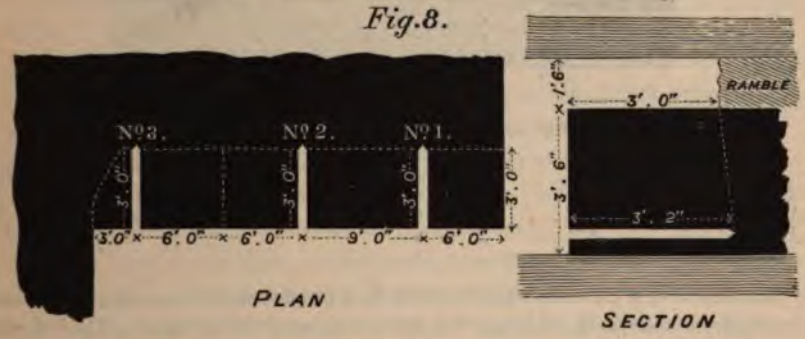
	Ft.	In.		Ft.	In.
Height of seam	3	4	Height of kirving in front... ...	1	0
Length of face	18	0	Depth of coal brought down at fast end	3	6
Distance of hole from fast end ...	9	0	Do. at loose end	3	6
Depth of hole	3	3			
Depth of kirving	3	6			

This was an experiment in lifting the jud, instead of pressing it down as is usually done. The coal was kirved at the top of the seam and a hole drilled for the machine in the bottom, about the middle of the jud. It was found that the whole of the coal was lifted square off by the back of the jud, tapering away at the fast side, as shown in the woodcut.

EXPERIMENT No. 18.

MAIN COAL SEAM, HASWELL COLLIERY.

Fig. 8.



Lifting Jud, kirved in Ramble at top of the seam. Three machine holes.

	Ft.	In.		Ft.	In.
Height of seam	3	6	Depth of holes	3	2
Length of face	30	0	Depth of kirving	3	0
Distance of No. 1 hole from loose end	6	0	Height of kirving in front... ...	1	6
Distance of No. 2 hole from loose end	15	0	Depth of coal brought down at fast end	3	0
Distance of No. 3 hole from fast end	3	0	Do. loose end	3	0
			Do. centre	3	0

EXPERIMENT No. 18.—Continued.

This was a second experiment in lifting the jud. The kirving was in 1 foot 6 inches of ramble, which was kirved into 3 feet. The holes for the machine were drilled at the bottom. The first two holes were put in next the loose side, and two machines were worked simultaneously, when the coal was lifted to within three yards of the fast side. Another hole was then put in one yard from fast side, which lifted the remainder of the jud, bringing it off at the fast side as shown in woodcut.

The coal next the ramble is a little tender, and in ordinary working yields too much small; but in this experiment it was found to come away in large pieces without any waste.

EXPERIMENT No. 19.

Ryhope Colliery.—Experiment made in Stone.

Fig. 9.

Taking down Top Canch for wagonway height. One machine hole.

	Ft.	In.		Ft.	In.
Thickness of canch	2	0	Stone brought down, length ...	6	0
Width of do.	8	6	Do. width ...	8	0
Depth of hole	3	2			

Machine tried at top canch 24 inches thick by 8 feet 6 inches wide; a plank was fixed by two props underneath the line of hole before wedging was commenced. The hole was bored 3 feet 2 inches deep. After forcing the wedge up to its full extent the props were withdrawn, when a large quantity of the stone came down, the remainder hanging ready for pinching down. This cleared a space 6 feet in length by 8 feet in width.

Time occupied in boring and wedging, 75 minutes.

EXPERIMENT No. 20.

RYHOPE COLLIERY.—EXPERIMENT MADE IN SEGGAR CLAY STONE.

Fig. 10.

Taking up Bottom Canch for wagonway height. One machine hole.

	Ft.	In.		Ft.	In.
Thickness of canch	1	6	Depth of hole	3	0
Width of do.	8	6	Stone broken up, length	3	0
			Do. width	6	0

The bottom canch composed of seggar clay stone. Machine lifted a space of 3 feet in length by 6 feet in width, leaving stone ready for pulling out with the pick.
Time occupied in boring and wedging, 105 minutes.

Mr. RICHARDSON asked what amount of force can be exerted by the screw?

Mr. HALL—It altogether depends upon the strength of the machine. In the machine described a force of 140 tons can be exerted against the sides of the hole, but he had made one which would have double that force.

Mr. RICHARD FORSTER said, he was present at some experiments at Haswell Colliery, and could fully bear out what Mr. Hall had stated. At the Low Main, Haswell, the machine was an absolute success. In juds it did its work more efficiently than powder could have done; in fast places it was wonderful to see how two wedges could force the coal out. He had tried experiments with it in very much thicker seams, up to 6 feet, and it satisfied him that all that was required was to increase the power of the machine according to the strength of the coal. In a 5 feet 11 inches seam, in board and wall working, with kirving and nicking to a depth of 3 feet 6 inches, coal was brought down by this machine, but not so effectually as at Haswell, because the men did not know the seam so well, and consequently did not know so well where to place the machine. In another

case, in a 5 feet 11 inches seam, a jud in a four-yard place was wedged down almost in a solid block with one hole. A similar experiment was made in the same seam with the kirving on the top, but whilst the coal was beginning to give way, the pressure and weight of it proved too great and the machine broke, not from any defect in the principle, but from want of power. As this machine could be used in a place where powder could not be used, it would be a very useful instrument in making height for rolleyways in seams where it was deemed inadvisable to use powder. He considered Mr. Hall had expressed himself too severely on gunpowder. In certain conditions he thought powder could be used as safely in mines as it could be in that room; and in other conditions it was undesirable to use it. If they had, in this machine, got something which could be substituted for manual labour in places where powder could not be used, then Mr. Hall had conferred a great boon on the coal trade.

Mr. STEAVENSON said, he must congratulate Mr. Hall upon having, to a great extent, overcome the difficulties attendant on the use of machinery in substitution of powder in mines, if the wedge was successful it would contribute greatly to increase the safety of mining operations. He would like to compare the pressure afforded by this machine with that of their old friend, blasting powder, for in approaching the consideration of such questions as the exchange of a wedge for a well tried explosive, it seems natural to ascertain as closely as possible, what work was done or what pressure was exerted by the medium it was proposed to supplant.

There are few explosives which he had not at some time practically tested, and as an instance of the great difference in result accordingly as pressure is applied suddenly or the reverse, he might mention that in the case of nitro-glycerine, the very suddenness of its explosion prevents it in some cases doing useful work, thus, for Cleveland stone it was of no use, while, on the other hand, explosive pressure applied too slowly allows an expansion which virtually wastes the work done.

The explosive force of blasting powder naturally varies with its quality, and—when trying, as he had done at various times, wedges of different kinds, amongst others the hydraulic—he had sought out various authorities on the subject, and all seemed to agree that the temperature of the gas of powder at the time of explosion in a shot-hole, varies from 2,000° to 2,200° Centigrade (3,990° Fahrenheit), and that the volume of the gas is 2,000 to 3,000 times the volume of the powder. Bunsen and Schishkoff, experimenting with sporting powder containing about 79 per cent. of

saltpetre, found that the temperature in a close vessel reached 3,340° Centigrade (6,043° Fahrenheit), and a corresponding pressure of 4,500 atmospheres, or 67,000 lbs. per square inch.

But of course mining powder, with say 66 per cent. of saltpetre, gives a less temperature, with large grains it burns more slowly, and in the shot-hole the gas is more rapidly cooled.

Professor Abel and Captain Noble, with perhaps more accurate means of testing, have given a pressure of 6,400 atmospheres or 94,000 lbs. or 42 tons per square inch; and here it may incidentally be mentioned that on the Continent, from calculations based on Mariotte's Law, Dr. Gurlt has sought, by giving the explosive space for expanding in the shot-hole to three times its bulk, to lower the temperature of the gases after explosion to, say, 666° Centigrade (1,231° Fahrenheit), which would be a heat too low to explode the gas of the mine, since according to the experiments of Mallard and Le Châtelier, the temperature required to fire any mixture of fire-damp is not below 780° Centigrade (1,436° Fahrenheit), which is increased when, as is generally the case, carbonic acid is present.

Interesting researches on the decomposition of explosives and composition of gases evolved were also given by MM. Sarsow and Vielle, in 1880.

He had himself, in the last twenty years, tried at least twenty different explosives, and none had approached the efficiency of powder. Although in experiment powder exerted 42 tons per inch, he thought in practice not more than 20 tons pressure could be obtained; but still, with 20 tons pressure, it would be interesting to compare the action of the wedge with it. He understood from Mr. Hall that there was a pressure of something like 140 tons on the wedge or about $1\frac{2}{3}$ tons per square inch. He would like to know how this had been arrived at, and whether any actual test had been made. With a wedge in which he had lately taken some interest, he got a pressure of 40 tons at the time the coal came down. He took the area of the hole at about 44 inches, and that would give something like one ton to the square inch. It might be a question how a wedge, with only one ton to the inch, could effect the same work that blasting powder, with a pressure of 20 tons to the square inch, could do. The difference must be found, he thought, in the fact that the wedge continued its pressure after the coal began to move; whilst the powder was sudden in its action. On the other hand there had been powder tried which was much too slow; some which he had tried a few years ago propelled the gases after explosion through the pricker hole, and made a tremendous noise, like a whistle; but there could be no doubt that the pressure of powder was beyond anything they could hope to apply with a wedge.

The pressure of powder might also be ascertained from the chemical changes which take place. 130 grains of powder equals in bulk 0·3 cubic inches of water, and its gaseous volume at atmospheric temperature equals 236 cubic inches; being an expansion of 1 volume into 787·3; but as the temperature of gas must be at least that of incandescence, this volume might be estimated at three times as much, or more than 2,000 times the bulk of the solid powder.

Further information on such subjects may be found in the Proceedings of the South Staffordshire Engineers for 1878, and in the "Engineer," of April 13th, 1883.

Another proposal in substitution of powder in mines, was that of M. Reuss, who put water into cartridges made of cast iron, about 14 inches long and 3 inches diameter, fitted at the end so as to receive a tube, and when the cartridge was inserted in the hole, a pressure of 20,000 lbs. per square inch was put upon it by means of a pump, at which pressure the cartridge (calculated on a basis that $\frac{1}{2}$ an inch thickness will burst at 6,700 lbs. pressure, and $\frac{1}{16}$ more or less, varies its strength 1,000 lbs.) burst, bringing down the coal.

Next comes the lime process. Mr. Paget Mosley, in his paper before the Iron and Steel Institute, puts the pressure of steam generated at 2,850 lbs., and if this is the highest which can be obtained in practice, it is easily seen how far it falls short of powder at 67,000 lbs.

But it may be compared another way, the theoretical heat evolved by one equivalent of lime (CaO) with one of water (H_2O) is per one part of lime 244·6 Cal. or equal to the heat required to raise 2·446 parts of water from 0° to 100° C., and on this basis for 1 lb. in English measures $\frac{180° \times 2{\cdot}446 \times 772}{2{,}240} = 150$ foot tons is obtained, whereas powder is equal to 480 foot tons.

As to the distribution of labour, he was inclined to think that instead of allowing the hewer to fill, he should get men to act as fillers. They found this division of labour to answer in Cleveland, where there was a great amount of drilling. With three mechanical drills they got about 630 tons in the two shifts, and that was about 105 tons from each machine in the shift. They had a skilled man with the drill, and an assistant not a skilled man, the shot firer, followed him; then there are the fillers, who had about 3s. a day, and so the valuable time of skilled men is economised as far as possible.

Professor MERIVALE asked Mr. Steavenson how he carried on the experiments with the wedge?

Mr. STEAVENSON said, in this case he had a length of lever—suppose three feet—on which were hung weights which, when multiplied by the various leverages afforded by the screw, the wedge, and the length of lever, gave the total pressure available to bring the coal down.

Mr. LAWRENCE said, that with regard to the pressure exerted by the apparatus, the screw was $\frac{3}{8}$th pitch, and $1\frac{3}{4}$ to 2 inches diameter. Mr. Steavenson was quite wrong if he imagined that the pressure was got by this screw alone. The 140 tons pressure was got by the addition of the several mechanical advantages gained by the screw, the levers, and the wedge, in addition to the length of the lever worked by the man. All these taken together gave about 182 tons as the pressure exerted by the wedge. Allowing $\frac{1}{8}$th for friction, this leaves 142 tons available for bringing down the coal.

Mr. W. F. HALL said, in reply to Mr. Steavenson's question as to the pressure of the wedge, compared with gunpowder, it had not been a question with him whether a machine could be produced that would exert as much pressure as gunpowder, only would it exert enough to bring down coal; he did not see that the pressure of powder, however interesting in itself, had any practical bearing on the question.

Mr. J. B. SIMPSON proposed a vote of thanks to Mr. Hall for his valuable paper. He hoped Mr. Hall would be able to carry out his improvements, which would cause quite a revolution in the system of working coal in this and other parts of the world, for if the use of gunpowder in mines could be dispensed with a great desideratum would be attained. He understood the principal experiments had been made in the Low Main; had experiments been made in such a seam as the Hutton Seam, or anywhere where the coal was much softer?

Mr. HALL—Yes; in Ryhope Colliery, where equally satisfactory results were obtained.

Mr. BEWICK seconded the vote of thanks, and it was agreed to.

The PRESIDENT—The paper will be open for discussion at the next meeting.

The paper by Mr. FRANK MURRAY STILL, on "Mining Coal by Compressed Lime," was announced for discussion.

Mr. STILL said, Mr. Smith happened to be in Newcastle that day, and he had asked him to attend the meeting, in order to give any information on technical or other points which might be required.

Mr. SEBASTIAN SMITH thanked them for giving him the privilege of saying a few words on this subject. At the previous meeting Mr. Logan called attention to the fact that the lime process was a very old one. He (Mr. Smith) knew that many years ago miners were accustomed to put dry lime into shot holes at night, and in the morning they found it had absorbed sufficient moisture to be of some little use. He might be allowed to say that in the patents taken out by himself and Mr. Moore, they specially disclaimed the idea of being the originators of the endeavour to use lime for coal-getting; because they were aware that great numbers connected with mining had tried to use it for he did not know how many years. If they turned to pages 11 and 13 of the Abstracts of Foreign Papers in Vol. XXXIII. of the Proceedings of the Institute relating to experiments made with explosives, they would find the following reference to experiments made with burnt lime:—"The increased diameter of bore-holes, the difficulty of the manufacture of cartridges, and the transport of the same, and the difficulty of pumping effectually the water into the lime, are obstacles which are not conducive to its general or even partial introduction." These happened to be the very identical points which he and his co-inventor, Mr. Moore, turned their attention to; and these were the difficulties they claimed, in a great measure, to have got over. By the introduction of more handy boring tackle they had been able to form the larger bore-holes required—some three inches in diameter—with great ease; and, after a very great deal of delay, they had got over the important difficulty, that of manufacturing cartridges. It was exceedingly difficult to obtain a machine which would exercise sufficient pressure and work at sufficient speed to make the cartridges of such commercial value as to let them be generally adopted. Messrs. Fielding & Platt, of Gloucester, had that week turned out a machine which would make upwards of 20 blocks a minute, which was very satisfactory. The most important point, however, of the invention was the method of introducing the water into the charge after it has been tamped up. The experiments were nearly completed at Woolwich Arsenal to determine the pressure exerted on the square inch. He spent three days last week at Woolwich, and the fact was established that the pressure of the steam alone was upwards of 42 cwts. to the inch; but from the want of sufficiently strong cast-iron cylinders, the effects of the expansion of the lime, which came after the steam was made, were not yet ascertained.

Mr. HENRY LAWRENCE'S paper "On the Danger of Sparks produced from Prickers and Stemmers used for Blasting purposes in Coal Mines, and Sparks otherwise produced" was then discussed.

Mr. LAWRENCE said, a great many experiments were being made, and he had had very good reports as to the results. The difficulty he had had to contend with up to the present time was that the stemmers and prickers were rather soft, and rather weaker than the mixture of copper and brass; but he was gradually getting over that. He had the satisfaction of knowing that wherever they had been tried—although they had not answered the purpose so far as strength was concerned—no one had been able to get a spark from them. He must endeavour to make them a little stronger, and he thought it could be done. They could be strengthened a great deal by hammering. Mr. Potter had several in use at the present time, and gave a good report of them; he had tried in every way and could not get a spark; and the managers of several other collieries gave the same report.

Mr. BIRD said that, granting Mr. Lawrence's metal would not itself produce a spark, there would still be the danger of sparks being produced between stone and stone in the hole. If Mr. Lawrence could introduce water in the hole during drilling, all danger of sparks would be removed.

The PRESIDENT said, he was very glad Mr. Lawrence saw his way to making them stronger. A pricker and stemmer were sent to him by Mr. Lawrence, and both of them broke before they had been many days in use. Unless Mr. Lawrence would make them stronger, the wear and consequent expense would be very great; because he considered that nothing could be done with them after they were broken.

Professor MERIVALE—Would not it be possible to make some inner core of stronger metal?

Mr. J. G. WEEKS said, he had recently read that a steamer, made of compressed paper, was afloat on one of the American lakes, and if that was so, would not compressed paper, moulded into proper shape, answer the same purpose as the new metal?

The PRESIDENT—At the last meeting he referred to wooden stemmers. Mr. Bewick and he were at a large lead mine the other day where wooden stemmers were successfully in use. He thought that the expense of wooden stemmers, owing to their breaking, would not be so great as the expense of Mr. Lawrence's stemmer from the same cause.

Mr. LAWRENCE said, that Mr. Bird's suggestion about introducing water into the hole when being stemmed meant that it would make

the sides of the hole so smooth that stemmers would not give off any sparks at all; but if they took a common stemmer, in a perfectly smooth hole, they would get a spark at every blow. He did not think the use of water would do. He was sorry that the sample stemmer which he sent to the President had turned out so bad; but he hoped to get over all the difficulties which had presented themselves up to the present time. He thought if they could get a stemmer that would not strike fire, the pricker must be used as in the old cases. There was no blow given on the pricker; and therefore the pricker formed a small portion in the work. The whole danger was the rammer coming in contact with the sides of the holes. He had no doubt they might get vulcanite or iron wood, which would answer the purpose; but, so far, he saw no reason why the improvements he had made in the stemmers should not effectually answer all the purposes.

Mr. BIRD said, that by the saturation of the dust and parts of stone in the drill hole by water, there would be safety against sparks.

ON THE STRENGTH OF WROUGHT IRON IN COMPRESSION.

By WIGHAM RICHARDSON.

The following letter from Mr. Wigham Richardson was read, in reference to some notes by him "On the Strength of Wrought Iron in Compression," which were published in Vol. XXXII. of the Transactions, page 180:—

Neptune Works (Ship and Engine Building),
Near Newcastle-upon-Tyne,
November 15th, 1883.

Theo. Wood Bunning, Esq.,

Dear Sir,—Referring to the note on page 180, Vol. XXXII., of your Transactions, I now have the pleasure to send you the tests made by Mr. Kirkaldy upon the strength of steel in compression. For convenience I give the former results also:—

EXPERIMENTS ON THE STRENGTH IN COMPRESSION.

Average of Several Pieces.

Diameter in Inches.	Length in Inches.	Stress Elastic per Square Inch. Tons.
I.—Tudhoe Iron.		
1½	2	14·895
1	2	13·958
¾	1½	14·047
¼	½	13·988
II.—Siemens-Martin Steel.		
1	2	15·893
¾	1½	15·312
¼	½	16·101

These have been followed up by more experiments made by the same person on specimens selected at random from material constantly used in our works. It may be of interest to print the full sheet of tests as well. I enclose them accordingly, but beg you will return them when done with.

The experiments upon steel fully confirm those made upon the Tudhoe iron, and show that the theory which I set up is not tenable, but at the same time it is evident that the formulæ in current use as to the strength of hollow pillars must be received with the very greatest caution. Indeed the whole subject requires experimental investigation.

Another point of interest is, that in compression, Siemens-Martin steel is only slightly stronger than iron.—Yours truly,

WIGHAM RICHARDSON.

TUDHOE IRON.

RESULTS OF EXPERIMENTS TO ASCERTAIN THE RESISTANCE TO DEPRESSION, UNDER A GRADUALLY INCREASED THRUSTING STRESS, OF TWELVE CYLINDERS, RECEIVED FROM MESSRS. WIGHAM RICHARDSON & CO.

Test No.	Description.	Dimensions.			Stress Elastic per Sq. In.	Depression.			Remarks.
		Dia.	Area.	Length.		At 50,000 lbs. per Sq. In.	At 100,000 lbs. per Sq. In.	At 150,000 lbs. per Sq. In.	
Q	Wrought Iron.	Inch.	Sq. In.	Inch.	Lbs.	%	%	%	
1176	1½" dia.	1·50	1·767	2·00	33,600	2·2	19·8	40·7	Barrel shaped.
1175	Do.	...	...	...	33,400	2·4	20·5	41·8	Do. cracked.
1174	Do.	...	...	...	33,100	2·6	20·8	42·0	Do. cracked.
				Mean	33,366	2·4	20·3	41·5	
1173	1" dia.	1·00	0·785	2·00	31,400	2·9	21·3	42·4	Barrel shaped.
1171	Do.	...	...	...	31.300	3·0	21·5	42·5	Do.
1172	Do.	...	...	...	31,100	3·0	21·6	42·6	Do.
				Mean	31,266	3·0	21·5	42·5	
1168	¾" dia.	0·75	0·441	1·50	32,500	2·6	20·7	40·6	Do.
1169	Do.	...	...	...	31,200	3·0	21·4	41·3	Do.
1170	Do.	...	...	...	30,700	3·2	21·7	41·6	Do.
				Mean	31,466	2·9	21·3	41·2	
1167	¼" dia.	0·25	0·049	0·50	31,500	3·6	22·4	41·0	Do.
1165	Do.	...	...	...	31,300	4·0	22·8	42·6	Do.
1166	Do.	...	...	...	31,200	4·2	23·2	43·0	Do.
				Mean	31,333	3·9	22·8	42·2	

MESSRS. WIGHAM RICHARDSON & CO.,

Neptune Works, near Newcastle-upon-Tyne.

(Signed) DAVID KIRKALDY.

99, Southwark Street, London, S.C., 18th April, 1882.

SIEMENS-MARTIN STEEL

(SOMETIMES CALLED, AND PERHAPS MORE CORRECTLY, INGOT IRON).

RESULTS OF EXPERIMENTS TO ASCERTAIN THE RESISTANCE TO DEPRESSION, UNDER A GRADUALLY INCREASED THRUSTING STRESS OF NINE CYLINDERS, RECEIVED FROM MESSRS. WIGHAM RICHARDSON & CO.

Test No.	Description.	Dimensions.			Stress Elastic per Sq. In.	Depression.			Remarks.
		Dia.	Area.	Length.		At 50,000 lbs. per Sq. In.	At 100,000 lbs. per Sq. In.	At 150,000 lbs. per Sq. In.	
R	"Siemens-Martin Steel."	Inch.	Sq. In.	Inch.	Lbs.	%	%	%	
3912	¼" dia.	·250	·049	0·488	36,500	2·6	18·4	35·8	Barrel shaped.
3913	Do.	...	...	...	35,800	2·6	18·4	35·8	Do.
3914	Do.	...	...	...	35,600	2·6	18·0	35·4	Do.
				Mean	35,966	2·6	18·2	35·6	
3915	¾" dia.	·750	·441	1·481	34,300	3·9	21·6	41·8	Do.
3916	Do.	...	...	...	34,300	3·9	21·6	41·8	Do.
3917	Do.	...	...	...	34,300	4·0	21·7	40·7	Do.
				Mean	34,300	3·9	21·6	41·4	
3918	1" dia.	1·00	·785	1·989	35,700	3·1	18·9	38·0	Do.
3919	Do.	...	...	...	35,700	3·1	19·0	38·1	Do.
3920	Do.	...	...	...	35,500	3·2	19·3	38·6	Do.
				Mean	35,600	3·1	19·0	38·2	

The ends of all the specimens required to be refaced here, as they were not true.

MESSRS. WIGHAM RICHARDSON & CO.,

Neptune Works, near Newcastle-upon-Tyne.

(Signed) DAVID KIRKALDY & SON.

99, Southwark Street, London, S.C., 6th October, 1883.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, FEBRUARY 9TH, 1884, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

GEORGE BAKER FORSTER, ESQ., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting and reported the proceedings of the Council.

The following gentlemen were elected, having been previously nominated:—

ASSOCIATE MEMBERS—

Mr. LAWRENCE W. ADAMSON, Whitley House, Whitley, Northumberland.

Mr. JACOB WALLAU, Gateshead-on-Tyne.

STUDENT—

Mr. MATTHEW BARRAS, Tudhoe Colliery, Spennymoor.

The following were nominated for election:—

ORDINARY MEMBERS—

Mr. JOHN JAMESON, Consulting Engineer, Akenside Hill, Newcastle-on-Tyne.

Mr. BENJAMIN JAMES FORREST, Mining Engineer, Calle de ras Infantas No. 18, Madras.

Mr. J. C. FORREST, Witley Coal Company, Limited, Halesowen, near Birmingham.

Mr. WILLIAM ASSHETON CROSS, Messrs. R. & W. Hawthorn, Newcastle-on-Tyne.

Professor G. A. LEBOUR read the following paper "On a Great Fault at Annstead, in North Northumberland:"—

ON A GREAT FAULT AT ANNSTEAD, IN NORTH NORTHUMBERLAND.

By G. A. LEBOUR, M.A., F.G.S.,
Professor of Geology in the Durham College of Science, Newcastle-upon-Tyne.

The object of this paper is two-fold: first, to draw attention to and describe one of the most complete natural sections, and one of the greatest dislocations, in the County of Northumberland; and, secondly, to give, in some detail, an example of the kind of reasoning by means of which an unseen fault may often be inferred with certainty. In order to attain this object it will be necessary, in the first place, to describe the rocks exposed along more than three miles of sea coast; to prove the existence of a concealed fault from the evidence supplied by those rocks; and, lastly, to show how far the probable characters of hade, throw, etc., pertaining to that fault may be estimated. The paper may, in fact, be regarded as being in part a contribution to local geology, and in part also a kind of exercise in practical geology.

INTRODUCTION.

Beginning at Ebba's Snook, as the northern point of Beadnell Bay is called, and proceeding along the coast, at low water, northwards (or, more properly, to the north-west), there is an absolutely continuous section of beds visible for a mile and a half, as far as the Annstead Rocks. After a short break at the mouth of Annstead Burn,* there is another continuous section from North Sunderland Point to the Tumblers Rocks, due east of Shoreston Hall. For the purposes of this paper these two continuous sections, together with the sandy beach intervening between them, are all that need be considered.

The beds exposed within these limits all belong to the great Bernician Series of Northumberland, and the uppermost among them at least to the

* Mr. N. Wood calls this stream Swinhoe Burn. The name adopted in this paper is the one given on the Ordnance Map.

Upper Bernician or Yoredale Rocks; but, as has been repeatedly shown elsewhere by the writer, there is nothing in this part of England to enable one to draw a line separating the Yoredale from the rest of the Carboniferous Limestone Series—hence, indeed, the chief utility of the term Bernician.

So perfect a section could not fail to attract the attention of geologists. It has been referred to by several,* but the late Mr. George Tate, F.G.S., of Alnwick, has alone attempted to describe its minor details.† Unfortunately, however, the measured section given by him is not taken altogether from the coast outcrops, but is made up, to a considerable extent, from information derived from more or less distant pit-sections inland. This being the case, and considering how great is the variability as regards detail of the Lower Carboniferous beds of the North of England, the value of Mr. Tate's section, for the particular purpose of this paper, is much reduced. Moreover, Mr. Tate's object in publishing his section was chiefly to give a general idea of the nature of what he called "the middle group of the mountain-limestone rocks," and the only reference made by him to the dislocations of the district is purely incidental. Under these circumstances the writer will, in the present paper, describe and figure the succession of the rocks from his own notes taken on the spot in the years 1879, 1881, and 1882, merely acknowledging as he proceeds such facts (principally thicknesses of coal-seams) as he finds it advisable to quote from the earlier observer. It may be mentioned that Mr. Tate's description refers only to the southern half of the coast-line treated of in the present paper.

SECTION FROM EBBA'S SNOOK TO ANNSTEAD BURN.

The following are the chief rock-divisions exposed between tide-marks along this portion of the coast. As the dip is to the south-east, and the section runs to the north-west from Ebba's Snook, the first stratum mentioned (No. 43) is the highest seam :—

43.—LIMESTONE.—This is Tate's "Ebb's Nook" Limestone, the well-known GREAT LIMESTONE of the southern part of the county. Here it contains a considerable and unusual amount of carbonate of magnesia.

* See especially the late Mr. Nicholas Wood's paper "On the Geology of a part of Northumberland and Cumberland."—Transactions of the Natural History Society of Northumberland and Durham, Vol. I., 1831, p. 309. This paper, so far as it describes this portion of the coast, is remarkably accurate.

The Geological Survey Maps of this district are, unfortunately, not yet published.

† See "Proceedings of the Berwickshire Naturalists' Club," Vol. IV., 1858, p. 96, and a reprint of the same paper in "The Geologist," Vol. II., 1859 p. 59.

42.—Principally SHALE, reddish and passing into sandstone above, blackish below, and with a COAL-SEAM about one foot thick at its base. This coal is the Dryburn Coal of the Lowick district.

41.—SANDSTONES, thin-bedded and shaly, passing to underclay above.

40.—SHALES and underclays.

39.—SANDSTONE, reddish and very coarse in places, coarse and yellow above.

38.—SHALE.

37.—LIMESTONE.—This is the "EIGHT-YARD LIMESTONE" of Central and the "FOUR-FATHOM LIMESTONE" of South Northumberland. A thin COAL-SEAM, six inches thick only, occurs at the base of this limestone.

36.—SANDSTONE.—Micaceous at the base, massive above, reddish, and in parts gannister-like.

35.—BLACK SHALE, with ironstone nodules. This is the same as the Brinkburn ironstone shale of the Coquet.

34.—LIMESTONE.—This is the "SIX-YARD LIMESTONE" of the Shilbottle district, and its outcrop forms the Blythe Rocks at Benthall. (See Fig. 1, Plate II.) There is another thin COAL (six inches thick) immediately underlying this limestone.

33.—SHALE.—Black, with ironstone nodules below, grey and micaceous above, and passing into underclay beneath the coal. The beds here grouped together under No. 33 are differently described in Tate's section.*

32′.—COAL.—One foot thick. This represents the "SHILBOTTLE SEAM" worked near Alnwick, where it is more than double this thickness.

32.—UNDERCLAY, passing to shale below, sandy above.

31.—SHALE, with ironstone nodules.

30.—SANDSTONE, thinly bedded, shaly.

29.—SHALE.

28.—LIMESTONE.—A thin bed, in two courses or "posts."

27.—SANDSTONE, with thin intercalations of shale.

	Ft.	In.
* "16.—Grey shales, with ironstone nodules	10	0
17.—Blue shales	15	0
18.—Grey slaty sandstone	5	0"

—See "Geologist" for 1859, Vol. II., p. 60.

26.—SHALE, thin, calcareous below, and full of fossils. This bed should more properly perhaps be regarded as the upper portion of the next (No. 25).*

25.—LIMESTONE.—This is the "BEADNELL LIMESTONE" of this portion of coast, and the same, as will presently be seen, as the "NORTH SUNDERLAND LIMESTONE," a little further north. A thin coal, of variable thickness (eight inches, according to Tate) and sometimes absent altogether, with its underclay, immediately underlies this limestone.

24.—SANDSTONE, much false-bedded, and containing irregular intercalations of shale. This stone is reddish, and gives its name to the Red Brae.† (See Map, Plate II.)

23.—SHALE.—This is a very inconstant bed, sometimes altogether wanting and sometimes seven feet thick in the same section of twenty or thirty yards.

22.—LIMESTONE.—A thin single-post bed.

21, 20, 19.—SANDSTONE AND SHALE.—A greyish yellow thick stone, very hard and compact in places, with irregular intercalations of shale. The lines of junction between the hard rock referred to and the shales are, at first sight, so unlike lines of bedding, as to simulate a series of small faults. Beadnell Haven is enclosed by this division. No. 20 assumes greater importance in the North Sunderland portion of the coast. Two coal seams occur in the upper part of these beds. The "Beadnell Coal," averaging about a yard in thickness, is the higher of the two, and has been much worked in the neighbourhood. The lower coal, though little more than a foot thick, has also been sometimes worked.

18.—SHALE, argillaceous below and micaceous above.

17.—LIMESTONE.—A thin single-post bed.

16.—SANDSTONE, micaceous and flaky, with a seam of coal at its base. This is the "Stone-close Coal," one foot four inches thick.

15.—SANDSTONE, passing to gannister-like underclay above, immediately beneath the coal.

* This is the "Black Dent, full of Cockle Shells," of Mr. Wood's section.

† Messrs. Henry Witham and Francis Forster remarked the colour of this sandstone in 1830, when they showed how many red beds of this character occurred in the Carboniferous Limestone Series between North Sunderland and Dunbar.—See Witham's paper "On the Red Sandstones of Berwickshire," in the Transactions of the Natural History Society of Northumberland and Durham, Vol. I., 1831, p. 176.

14.—SHALE.

13.—SANDSTONE.

12.—SHALE, thinly laminated, black, non-micaceous.

11.—LIMESTONE.—A marked bed consisting of three "posts." The lowest of these is much broken up by veinlets full of calcite. Two bands of fossiliferous calcareous shales intervene between the courses of limestone. A thin coal, a few inches thick, occurs directly below this bed.

10.—SANDSTONE, yellow.

9.—LIMESTONE.*—A two-post bed; the upper one massive and compact, and the lower thin, hard, rubbly, and weathering yellow externally. The "Swinhoe Coal," one foot four inches thick, lies, according to Tate, directly under this bed. The writer has, however, not been fortunate enough to see it in place, probably owing to its being concealed—as indeed most of the coal-seams in this section are apt to be—by accumulations of sand or by seaweed.

8.—SANDSTONE, thick yellow, brown, and reddish, much false-bedded.

7.—SHALE, thinly-laminated, black.

6.—LIMESTONE.—A bed made up of eight thin "posts," some of which are full of crinoids. A thin coal underlies this limestone.

5.—SHALE.—A thin calcareous bed.

4.—SANDSTONE, brown, massive, gannister-like, and white in parts. This is the horizon of the "Fleetham COAL," which, again, the writer has been unable to find. Its thickness, as given by Tate, is one foot six inches.

3.—SHALE, bluish-grey and micaceous.

2.—LIMESTONE, in thick posts (two ?). Very fossiliferous. A thin coal occurs at the base.

1.—SANDSTONE, brown, massive, false-bedded, rolling; white, hard, and gannister-like at the top.

* From this point it is not possible to correlate the beds as mapped on the ground and shown in the plan and section illustrating this paper with those given by Mr. Tate. This is probably not due to any inaccuracy on the part of that writer, but to the fact that his details were, as already mentioned, to a considerable extent taken from pit-sections at various distances from the coast. This discrepancy is the more to be regretted that there are one or two coal-seams of some local importance in this portion of the Bernician Series—such, for instance, as the "Swinhoe" and "Fleetham" seams. —See "Geologist," *loc. cit.*, p. 61.

The above include all the beds shown in continuous succession from Ebba's Snook northwards. Next comes the sandy flat, through which meanders the Annstead Burn, and where the Carboniferous rocks are concealed. They re-appear, however, after a short interval, a few yards south of North Sunderland Point, and from thence to the Tumblers Rocks there is another perfect section. The beds shown at first dip to the south like those of the Beadnell Section, and, in the ordinary course of things, would be regarded as lying some hundreds of feet below the latter. But even a rapid examination of the limestone at North Sunderland Point, and its accompanying beds, would soon lead one to recognize in them a set of strata already well seen in part of the Beadnell Section, and a careful collation of the available evidence on the subject would tend to confirm this view in every particular. The south-easterly dip does not continue far—not farther than the Braidcarr. The little bay formed at low-water between Braidcarr End and Southrock End coincides in fact with the east and west axis of a low-pitched anticlinal which brings about a reversal of the dips (which from that point to the Tumblers Rocks are north-west and north) and a consequent repetition of the beds shown in the southern half of this portion of the section. That the Tumblers Rocks are formed of the same beds as North Sunderland Point does not admit of any doubt, since the change of dip is quite obvious, and every bed is perfectly exposed, without a break, at low water. But that the beds thus repeated by an anticlinal fold are a further repetition of some of those described in the Beadnell Section, although clear enough to any one examining them in the field, may require some proof. This proof will best appear from a brief description of the North Sunderland Limestone and its associated deposits.

THE NORTH SUNDERLAND LIMESTONE.

This Limestone is, with the exception of the "Great" and "Four-fathom" Limestones, perhaps the most unmistakable limestone of the Bernician Series; it is also one of the best known in the northern half of the county. At North Sunderland it was formerly very extensively worked, the lime it yielded being considered quite the best in the district, and shipped to Perth, Aberdeen, and other distant ports. The quarries here have been given up, the writer is informed, solely because the Trustees of Lord Crewe's Charities, who are Lords of the Manor, refuse to allow any more coal-pits to be sunk about North Sunderland. The

bed is about 24 feet thick on an average, but being very irregularly bedded and much given to rolling and contortions, the thickness varies

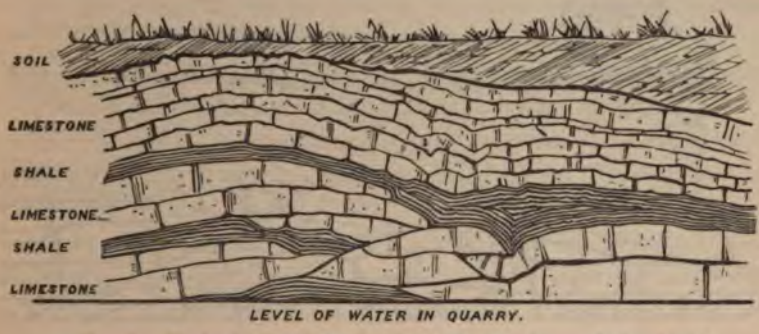


FIG. 1.—Section in North Sunderland Quarry, eastern end, showing the irregular bedding of the limestone and shale bands common in the North Sunderland Limestone (in lieu of strike).

considerably. The irregularities referred to are well shown in Figs. 1 and 2, which are drawings made to scale from points in the old quarries very near the line of section in Plate II. The irregular bedding is not confined

FIG. 2.—Section showing rolling beds of limestone and fault in North Sunderland Quarry, throwing about 4′ down to the east. Showing also the sandstone overlying the limestone.

to this locality, but is characteristic of this limestone at a distance, as in the Eelwell Quarries, at Lowick, for instance. (See Fig. 3.) In a former paper it has been stated that the Great Limestone is very frequently found rolling heavily in the south of the county;* this is the case, but this rolling is unaccompanied by the singular irregularities of bedding which are so constantly present in the North Sunderland Limestone, and more especially in its lower beds.

* See Transactions of the North of England Institute of Mining and Mechanical Engineers, Vol. XXIV., 1875, p. 140.

Mr. Tate enumerates 46 species of fossils from this limestone, and the writer has found a few more. It is true that none of these, taken

FIG. 3.—The Beadnell Limestone in Eelwell Quarry, Lowick, showing irregularities of bedding simulating reversed faults.

separately, can be said to be specially characteristic of this horizon in particular, but the assemblage of forms taken together is decidedly peculiar. There is, as the Map will show (Fig. 1, Plate II.), at the top of the limestone, a calcareous shale of small thickness. This little bed is very remarkable. It consists chiefly of a mass of small shells of the genera *Productus* and *Spirifer* (*Pr. longispinus* and *Sp. trigonalis*), mixed with isolated specimens of other fossils, among which some Trilobites and crinoidal calyces are the most noteworthy. Once seen this Productus and Spirifer bed cannot be mistaken, and it therefore affords a valuable means of recognizing the limestone upon which it rests.

A little way beneath the North Sunderland Limestone is another calcareous bed—a thin four-feet limestone in two "posts." Now this bed, like the larger one above, is capped by calcareous shale, also literally crammed with *Productus longispinus* and *Spirifer trigonalis*.

A little way above the North Sunderland Limestone there is yet another thin bed of limestone, in two "posts," separated by shaly sandstones from the first-mentioned shell bed.

Here there are several marked peculiarities, enabling one to fix the North Sunderland Limestone when it is met with, and to distinguish it from others, viz.:—

1.—It is about 24 feet thick, and is of exceptionally good quality for agricultural and other purposes.

2.—It very commonly rolls.

3.—Its lower posts are very irregularly bedded and mixed up with intercalated shales, which are constantly thickening and thinning within certain limits.

4.—The next limestone beds above and below it are both very thin and easily recognizable.

5.—The assemblage of fossils in this, the most fossiliferous limestone in North Northumberland, is peculiar.

6.—It is associated with two very remarkable shell-bands, one immediately above it, and the other a little way below it.

To these points, which would be more than sufficient for the identification of a thick limestone in the Bernician Series, add the fact that several well-known coals occur below the underlying thin limestone, and are or have been largely (or, more properly speaking, widely) worked, wherever the North Sunderland Limestone is known, and there should be no difficulty in knowing this bed wherever it and its associated strata are exposed.

THE BEADNELL LIMESTONE.

This bed, No. 25 in the Beadnell Section (Plate II.), fulfils all the above conditions.

It is about 24 feet thick; it yields the same quality of lime; it rolls and is irregularly bedded; it lies between two thin limestones; its fossils are those of the North Sunderland Limestone; it is capped by a *Productus* and *Spirifer* bed, and another like it caps the lower thin limestone beneath it; and in the beds below the latter the "Beadnell Coals" are known and worked, and are of the same quality, thickness (generally speaking), and relations to their associated strata, as the coals at North Sunderland.

In a word, the Beadnell Limestone of Red Brae Point is the same bed as the North Sunderland Limestone of North Sunderland Point and of the Tumblers Rocks, and the beds are numbered in the Map and Section accordingly.

THE ANNSTEAD FAULT.

It remains to be shown how this repetition of the beds 19 to 28, north of the Annstead Sands, has been brought about. A fold of the rocks will not serve one's purpose. A glance at the Map will show such a fold, synclinal or anticlinal, or even an inversion, to be impossible. Nothing, therefore, is left to account for the undoubted facts but a fault. Within certain limits, the place of that fault or faults (for, on the evidence given, it cannot be proved that there is but one fault, though, from other considerations, it is probable that this is the case), is plainly marked out. It *must* run somewhere beneath the Annstead Sands, between No. 1 of the Beadnell

Section and No. 28 of the North Sunderland Section. There is no reason for placing it at any particular point within these limits rather than at any other, and, therefore, the central point has been chosen for it on Plan and Section (Plate II.) as that least liable to error. Of the exact direction of this fault there is little indication in the evidence brought forward in this paper, except that in a general way it is east and west.* Of its hade nothing can be *known* from the facts given, and it has, therefore, been drawn vertical, to avoid marking anything on the Section for which there was no warrant from surface observations; but it may be guessed that since the downthrow is to the north the fault will incline probably in that direction. That the downthrow *is* to the north needs no proof, since on that side high beds (Nos. 28, etc.,) are brought down to the level of lower beds (Nos. 1, etc.,) on the south side.

With regard to the amount of the downthrow a little more discussion is requisite. The degree of accuracy to which it can be arrived at depends chiefly upon two points, viz.:—the dip observations of the exposed beds in the Beadnell Section, and the behaviour of the beds concealed beneath the Annstead Sands on either side of the fault. The former point is a matter of care and of the personal equation of the observer, the latter is confessedly a matter for shrewd guesswork based on experience.

First, as to the dips of the Beadnell Section. They are beautifully shown all the way from Ebba's Snook (Beadnell Point) to the Annstead Rocks. They are nearly uniform as far as the Linkhouse. (See Map, Fig. 1, Plate II.) As to the direction of the dip there can be no question. It is south-easterly. As to its amount there should be no question either, nevertheless, Mr. Tate makes it 15 degrees, and the writer 8 to 10 degrees.† As Mr. Tate does not mention having taken any special care in taking the dips, as he does not even mention the change of dip both in direction and amount beyond the Linkhouse, and as the ground covered by his paper did not extend to the fault, or make the consideration of the question of dips of any particular importance, the writer prefers to stand by his own reading. At the Annstead Rocks, opposite the Linkhouse, however, the dip very rapidly changes from south-east to south and then

* Inland observations prove this view to be correct.

† The Hon. Henry G. Bennet, in a paper describing the basaltic dyke at Beadnell (Transactions of the Geological Society, Vol. IV., p. 102), gives the dip of the beds here as one yard in six, which is 10 degrees; Mr. N. Wood makes it 7 degrees. Both observations are accurate for various parts of the Section. The mean dip being somewhat nearer 10 degrees than 7 degrees, Mr. Tate's 15 degrees is certainly much too high.

to south-west. It is south-west where the sands begin and the last rocks south of the fault are seen. In a section drawn in the line selected in Plate II. the change of dip is shown by the gradual flattening of the dotted line representing the unseen base of No. 1. This does not mean that the beds are here really horizontal, but that the line of section being here, owing to the altered dip, coincident with the line of strike, no dip is apparent in the section.*

The element of doubt, as has been admitted above, lies in the ignorance one is left in with regard to the continuation or alteration of the observed dips. On the north side of the fault, that is, on the downthrow side, the beds 25 to 28 are dipping very regularly towards the fault at 10 degrees where last seen. There is no sign of change of direction here as there is at the Annstead Rocks, and since this, the arrangement so common in the Newcastle Coal-field, namely, dip to an upthrow or "dip to a *riser*," though not that usually found described in text-books, there is no reason for not continuing the lines of the beds beneath the sands with the same direction and amount of dip as far as the fault. It must be confessed that it is not so safe to proceed in a similar manner on the south side; nevertheless, since there is no evidence at hand respecting the behaviour of the dips between the last seen slope of the Annstead Rocks and the fault, which, after all, *may* be quite close to that point, there is no reason for disturbing the horizontal dotted line which shows the apparent dip of the base of No. 1 in the Section, and for not continuing that line to the fault. It may be noted that if one be right in continuing the dips on either side of the fault towards it as they are last seen, the position of the fault becomes of material importance in discovering the exact amount of its throw, since wherever it be shifted to within its possible limits the level of the beds on the south side remain unchanged, whereas that of those on the other deepens the more southerly in the fault's position. In the extreme possible case a difference of 300 feet in the throw might thus take place without surface evidence thereof.

* Mr. N. Wood noticed this change of dip. He says, referring to the bed numbered 43 above, "Hard reddish sandstone rock, stretching along the coast for about a quarter of a mile, the inclination of which gradually alters, and finally becomes quite flat, probably the effect of some "Slip Dykes." He also evidently regarded the rocks about North Sunderland as being some of those forming the Beadnell Section repeated, for he proceeds: "After passing a flat sandy beach of about a quarter of a mile, we find a series of beds of sandstone, shale, and limestone, *apparently part of the preceding thrown down* by the Slip Dykes previously noticed."—*Loc. cit.*, p. 310. The italics in the quotation are the writer's, not Mr. Wood's. The latter, however, not having attempted to identify the beds, could naturally have no reason to suspect the great throw of the fault causing the repetition.

Producing the line of the base of bed No. 25 (the Beadnell Limestone) at the same dip as that observed at the Red Brae, until it reaches the line of fault produced upwards at z, the throw would be $x\,z = 1{,}200$ feet. But in doing this no notice has been taken of the change of dip and consequent apparent flattening of the beds past the Linkhouse northwards. Rectifying this, the produced base of No. 25 would reach the fault at y, giving a throw of little less than a thousand feet, or, more exactly, 980 feet. This is the most probable throw of the Annstead Fault, where it underlies the Annstead Sands, from the evidence brought forward in this paper.*

The PRESIDENT said he was sure they must all have been very much interested in hearing Professor Lebour's paper, and he was certain that if anyone chose to spend a day, between now and the time of the discussion, in inspecting the section, they would find it in a very pleasant neighbourhood, and would see some interesting geological features.

Mr. JOHN MARLEY proposed a vote of thanks to Professor Lebour for the paper, the publication of which would, he said, induce not only young students, but perhaps some of the older members also, to visit the place and see for themselves the beautiful panorama of strata there illustrated.

The motion was agreed to.

The SECRETARY read the following "Remarks on Lightning in the Pit at West Thornley Colliery," written by Mr. HENRY WHITE:—

* If Mr. Tate's dip of 15 degrees be adopted, the amount of throw would be $x\,z' = 1{,}700$ feet. That the throw should be so abnormally great would in itself, in the absence of confirmatory evidence, tend to prove the dip as being much overestimated.

REMARKS ON LIGHTNING IN THE PIT AT WEST THORNLEY COLLIERY, ON DECEMBER 11TH, 1883.

By HENRY WHITE.

As it seems the belief of many people that lightning cannot descend into the workings of a pit, the writer has thought that it might be desirable to add another well authenticated record of the presence of the electric fluid in a mine during a thunderstorm to the one at Tanfield Moor already recorded in page 31, Vol. XXX. of the Transactions of the Institute.

West Thornley Colliery (which has three times been the site of electrical discharges) is situated about a mile from Tow Law, which is 1,000 feet above the sea level; it is 25 fathoms deep, and is sheltered by a hill on the south side 50 feet high, which commences to rise about 50 yards from the pit, the ground on all other sides being fairly level.

The steam boiler chimney was 46 feet high, 12 feet south-west from the engine house, and 68 feet south-west from the centre of the pit.

The pulleys are 53 feet from the surface. The ropes are made of plough steel, the cages of steel, the guides or skeats are made of iron rails, secured by wrought iron buntons, and there are four rapper ropes in the pit, two of which only reach to the bottom seam. There are three ranges of pipes in the pit, viz., a sett of 5-inch steam pipes *a*, Plate III. covered with patent composition, which lead into a receiver *x* at the pit bottom, and from it to the underground hauling engine *y*, which is 40 yards on the south side of the pit bottom. A second range consists of an 8-inch rising main *b*, which rests upon a large balk at pit bottom, and a third range *c* of 10-inch pipes, which goes into the sump about 15 feet below the flat sheets, and is now used for conveying exhaust steam to bank.

About 10 P.M. on Tuesday, December 11th, 1883, there was a violent wind, with heavy rain, accompanied with much thunder and lightning. About 10·15 the winding engine brakesman, Mark Adams, who was watching the storm out of the engine house east window, saw a flash of forked lightning about the pulleys, and heard a heavy peal of thunder,

and about five minutes afterwards, at 10·20, when still looking out of the window, saw another brilliant flash of forked lightning strike the pulleys and light everything up in a blaze, almost blinding him, instantly accompanied by a terrific clap of thunder. Hearing a great noise on the other or west side of the engine house, he opened the door and found the boiler chimney had been struck at the top on the north-west side, and a large zigzag rent made on the west side, varying in width from a few inches to two feet and reaching to within about 15 feet from the bottom, and bricks and lime were falling all over the place.

Robert Emery, the master shifter, who was engaged about three yards from the shaft bottom, said he heard brattles of thunder about 10 o'clock, and between that and 10·20 he heard a very heavy one, when at the same time a flash of lightning came down the pit on the south-west side, and apparantly down the rapper rope *r'*, glancing from the rapper handle, which pointed at an angle of 45 degrees towards the 5-inch steam pipes *a*, which were about three feet off and uncovered at that point, and producing a brilliant light and a noise like that of the firing of a gun.

There are metal flat sheets on both sides of the pit.

There were no marks of damage about, but the flash seemed to have left behind a sort of vapour which appeared to pass along the steam pipes inbye, and it may be assumed that the lightning struck the pulleys and went down the winding rope to the cages, which were standing in the shaft, and then passed to the rapper rope.

John Craggs, shifter, who was also working at the pit bottom, confirmed the above statement.

This occurrence the writer has investigated with great care, and puts it forth as a statement entitled to every credence; the following statements refer to the two previous discharges that had been noticed:—

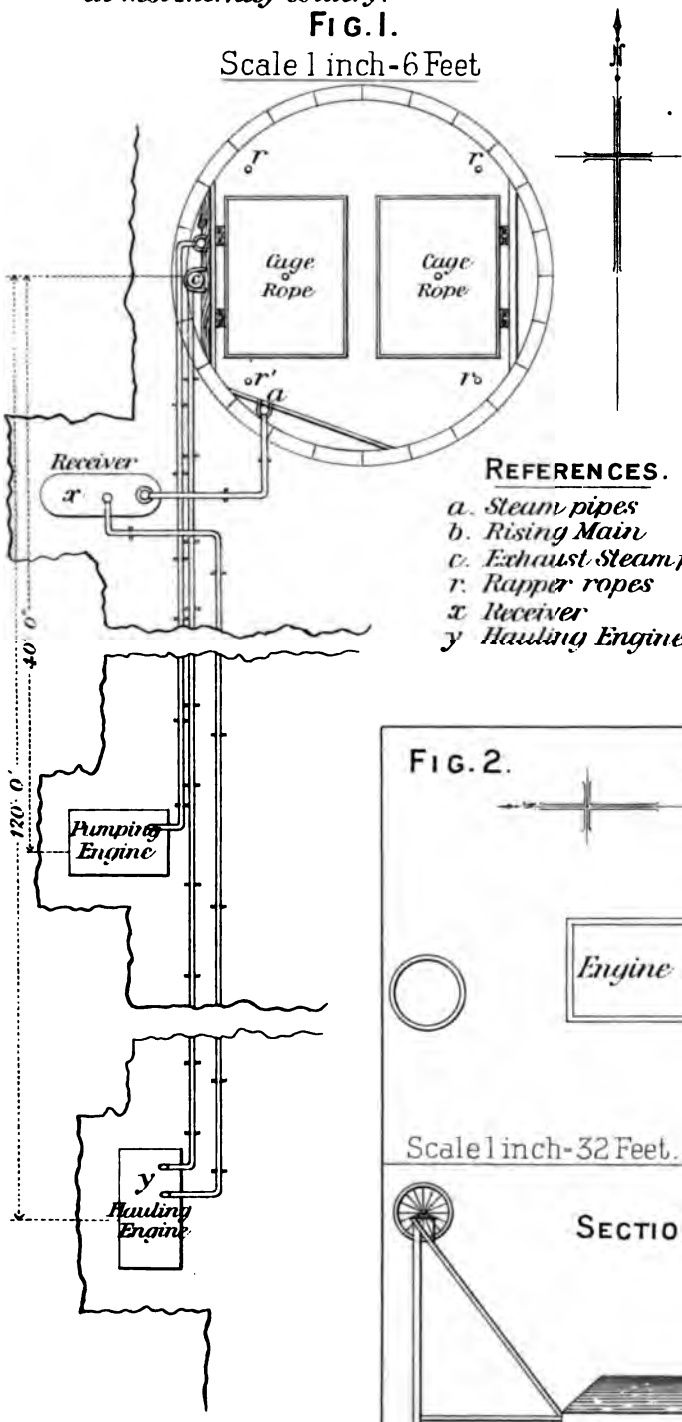
About three years ago, in the summer, and during the middle of the day, W. Newton, onsetter, said a flash of lightning came down the pit and appeared to strike the flat sheets on the north-west side, making a very brilliant light, and a report louder than any gun. Those at the pit bottom also saw it and were very much frightened.

At the same time the underground hauling engineman had his hand on the throttle valve handle and felt a strong shock in his wrist and arm, and saw the lightning most distinctly. Two shifters who were working about 15 yards from him saw the lightning most distinctly through a stenton at right angles, but there were no rails or pipes to conduct it to them through the stenton.

To illustrate Mr. H. White's paper "On Lightning in the Pit at West Thornley Colliery."

FIG. 1.

Scale 1 inch - 6 Feet

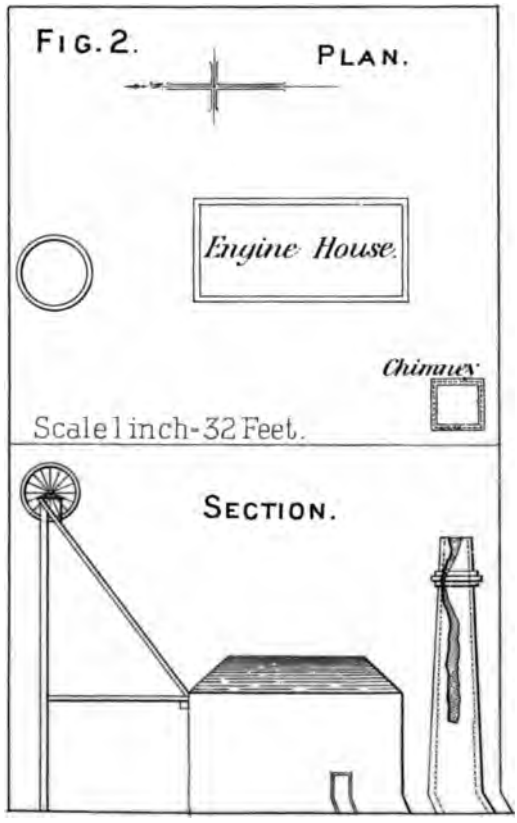


REFERENCES.

a. Steam pipes
b. Rising Main
c. Exhaust Steam pipes
r. Rapper ropes
x Receiver
y Hauling Engine

FIG. 2.

PLAN.



About fifteen years ago, at mid-day, when W. Newton was then banking out, and had his hand on the cage sneck, there was a very vivid flash of lightning, and he experienced a very severe shock in his arm and feet, and considerable pain and numbness for the remainder of the day.

It would appear in this case, too, as if the lightning had struck the winding rope, passed through the cage, which was at bank, to the skeats, and gone down the pit, at the bottom of which it was most distinctly seen. It then struck one of the flat sheets, and broke it into several pieces, passing probably along the rails to the face of the south stone drift, which was then about 80 yards from the pit bottom, and was most distinctly seen there by two stonemen who were getting their baits, who said that it lighted up the whole place.

Having had some conversation with Mr. Massingham, Dean Street, Newcastle, who has had large experience in putting up lightning conductors, etc., the writer asked him if he knew of any local reasons why this pit should have been so often struck, and he replied that when once a place had been struck by lightning it was rendered more liable to be struck again for some time after, and that some parts of the earth, owing to the nature of the soil, etc. (which at West Thornley was a wet bluish clay probably with metallic veins running through), had a greater affinity for lightning than a dry soil of sand, chalk, or granite.

When asked as to the area or space a conductor would protect, he said it was now generally agreed that the area protected was in the form of a cone whose base was equal to its height, so that it would appear all chimneys or buildings a certain distance apart should have a separate conductor; and he was of opinion that the lightning, being forked, had struck the West Thornley chimney and pulleys simultaneously, and that a conductor on the chimney would not in all probability have prevented the lightning going down the pit.

The pit being an upcast, the warm current of air would offer a great inducement to the lightning. All lightning conductors should be tested about once a year, as, owing to alterations, repairs, and earth connections being disturbed, they are apt to get out of order.

Mr. S. F. Walker said, he thought the thanks of every person interested in this question were due to the author of this paper for the very careful way in which he had given them all the details. The action of lightning was the most difficult branch of electrical study that he knew of; and its difficulty was principally due to the fact that lightning was

always doing something they did not expect. Lightning apparently acted in a promiscuous sort of way, and went where it liked, and did as much damage as it could, and there was no guarding against it; but he thought if they carried the matter back to first principles they would find the whole thing was simple enough; in fact, the difficulties were due entirely to the enormous tension at which the charge—which was the force through which lightning acted—was generated. He thought the same kind of difficulty was experienced in regard to the smelting of iron. So far as he knew, in regard to smelting, there were enormous heats, and up to very recently, he believed, there was no method of testing the actual degree of heat which was required to complete the process, and still less the heat that was necessary economically to do so; simply because nobody could get near enough to measure the heat in the furnace with any degree of certainty. So they were under the same difficulty with lightning, because they had no lightning test. If they could know the conditions which were present in the lightning discharge, they could possibly find out all it could do, and all it could not do; but they could not have that knowledge, because the tension, so far as they were able to judge by reasoning upon the actual facts under which the lightning acted, was enormously in excess of any tension they could possibly experiment with. Dr. Spottiswoode, the late President of the Royal Society, and Dr. De la Rue, had spent many years in experimenting on this subject, and built up a battery of some 10,000 cells; but they did not get anything near the tension, not the hundredth part of the tension perhaps, developed in the ordinary lightning flash. When they knew the difficulty of setting up 10,000 cells, and keeping up the insulation, they could imagine the immense difficulty of finding out what really took place in a case such as now reported. They could only judge by reasoning as closely as they could upon what took place from time to time, and from a careful comparison of the different results they knew. Lightning was merely a very powerful electric spark; it was only a discharge from a cloud very highly charged. It was little matter how the cloud gathered it, or generated it; the charge would be increased by its friction with the atmosphere as it blew along by the action of the wind. The air had an enormous resistance. The current equalled the force divided by the resistance. If the resistance was one million Ohms (and it might easily be many millions) it was necessary that there should be a hundredth part of that force between the cloud and the object which it was to strike, for it to deliver the current necessary to pass the spark; and so long as it did not get that difference in the tension, and satisfy that condition, no current could pass. The

action of a cloud probably was that it would acquire higher and higher tension as it passed along, and he thought he was right in stating that in the case of thundery weather, the cloud came lower and lower, and the atmosphere between the cloud and the earth became more impregnated with moisture than on an ordinary day, and, therefore, the conditions of discharge became more and more favourable. As the cloud passed along, any elevated object, such as a chimney stack or a head stock, or anything high would reduce the resistance very considerably. A chimney 200 feet high would reduce it enormously; because the resistance of 200 feet of air would be enormously in excess of the resistance of 200 feet of dry brickwork, or perhaps wet brickwork. Bricks were porous, and when exposed to the atmosphere they would probably fill to a certain extent with moisture; while deposited inside the chimney there was usually a very compact layer of carbon, with it might be some salts, so that the chimney itself might be by no means a bad conductor, and the mere approach of a cloud might determine the conditions of the discharge, and it might be that when a cloud arrived within a certain distance of a certain chimney the resistance might be sufficiently low to enable it to pass the required current. But in determining the resistance they had to consider the whole of the parts of the chimney. The outside brickwork was one part, and the inside of the chimney leading to the furnace, and more or less in metallic connection with the boiler, was another. The heated air and smoke from the chimney would also lessen the resistance. If there was a lightning conductor on the chimney it would deliver the whole of the charge, no matter how great it might be, silently into the earth, provided it was carried sufficiently above the chimney, and was in such a position that the resistance offered by the lightning conductor was very much less than any other resistance. It would be useless for a lightning conductor to be at such a distance from the object it was intended to protect, that the resistance offered by the distance between it and the cloud left a fair path in some other direction not protected. There was another law in electricity which said that when a current had two or more paths open to it, it divided in the inverse proportion to the resistance, the largest portion went to where the smaller resistance was, and the smaller portion to where there was the largest resistance. In this case the lightning appeared to have divided, so far as he could see, into five or six different paths. There were two parts in the chimney itself—the brickwork of the chimney, and the inside of the chimney leading to the furnace—where the discharge would take place naturally. Whatever

the cause, the share of the charge which the chimney itself took was sufficiently great to do considerable damage. There was another law, and that was, that where a current encountered resistance it did damage in exact proportion to the resistance it encountered. If the current was large it developed heat according to the square of the current. If the current was small and the force large, the damage would be as the square of the force. In this case the current going down the chimney might be very small, but the force would be so large as to be sufficient to do the damage that was done. Then another portion would strike the pulleys. The head stocks were of wood but the pulleys would be iron, and would be in connection with the rope, but not in perfect electrical connection, because there was always a good deal of grease, and grease was not a good conductor; consequently the current would again split, and part would go down the rope. Another law was, that when there was a charge of electricity, involving a very small quantity, but at very high tension, if any other object were brought in connection with it, or near it, as a conductor, it would take a portion of that charge. In this case the rope and engine would relieve the charge of a large portion of its intensity and another part would pass on to the boiler, and to the feed place or pond where the water was drawn from. It was his opinion that if the ropes were in perfect electrical connection with the pulleys and the pond made good earth no charge would have found its way down the pit. It was owing to the imperfect connection between the ropes and the pulleys, and again, probably, the drums and the ropes, owing to the layer of grease which offered a certain resistance to the passage of the charge, that a portion went down the rope leading into the pit and to both cages. The cages, he presumed, would be in connection with the guides, and the guides would take a portion of the charge, and the cages a portion. The guides would carry the charge into the sump, where still more of it would be dissipated. If the sump were making perfect earth, and able to dissipate the whole of the charge, there would be no flash going to the rapper handle, but the sump took only a certain portion of the charge, the sides of the shaft another portion, the pipes another portion, and still there was enough left to get to the rapper wire. He thought most probably the original flash struck at the same time the pulley and something in connection with the rapper wire. Then the charge going down this wire apparently could find only one outlet, and flashed across to the pipes which led away to the hauling engine, in connection with which there was always a mass of metals, rails, and rope in addition to the whole

mass of coal. A gentleman made experiments in South Wales, about two years ago, on this subject—which, however, he had not had time to verify—to prove that coal, although an imperfect conductor, would, if the tension was high, accept a charge. If that were so, and if the charge did find its way into the mine, the enormous surface of the mine would lead the charge away, and it would be dissipated. So far as he could learn, in every case he knew of, that seemed to be the course the lightning adopted. In one of the other cases mentioned, the man at the underground hauling engine saw the lightning and received a shock in his hand or arm, and men some distance off, round a corner, saw the lightning, as well. There were two explanations of this. One was that it was an optical effect, and the other that it was electrical. He was inclined to think that what the men saw was the remainder of the charge distributing itself harmlessly over the coal, and he was borne out in this opinion by the fact that no harm seemed to have been done. In no case where lightning penetrated into a pit had any man been seriously injured by what was left. It had been said that explosions had occurred, but he had seen no conclusive proof of that. The mere fact of a charge with all these paths open to it still finding its way down, and then only hurting a man's arm and doing no serious injury, was conclusive proof that the charge must have been considerably dissipated. He believed the cases in which lightning descended a pit were very few indeed, and he did not know of any properly authenticated instance in a working mine of an explosion occurring through lightning. He did not say it could not take place; but to be safe, a properly fixed lightning conductor, as large and with as many points in as many different directions as possible, should be carried above the head stock as high as possible, and the end carried into good damp ground or a river. If such a lightning conductor were placed over every colliery in the kingdom they would not hear of lightning going underground into workings. The first office of a lightning conductor was to discharge the cloud long before it arrived at the object which the conductor was to protect. What was known as the first discharge took place at the points of a lightning conductor, and the area over which it was discharged would be very great. They had in Germany, or they had some years ago, a very large machine, and the brush discharge from that machine was, he thought, 30 feet. If that were so with the comparatively small tension they were able to get with the largest and most perfect machine they could make, then the brush discharge from a point with a charge of far higher

tension must be very much greater than that. The second office of the conductor was this—It might happen that, notwithstanding the brush discharge, the charged cloud would be driven along by a strong wind, and arrive at the object before the conductor had time to discharge it, in that case the conductor would take it harmlessly to earth. If the conductor was properly fixed, and had the capability of conducting the highest current and the greatest tension, then it ought to be possible to take that conductor through a powder magazine without doing any harm. The human body—the object most sensitive to electricity he knew of—would probably not feel it, always provided the conductor were perfect. Conductors required to be looked at occasionally, for it became a serious matter if the conductor were tampered with, and the defect not found out. He understood there had been a controversy in the North as to whether lightning went from the earth to the cloud or from the cloud to the earth, and that there were no such thing as discharges, but only thunderbolts. So far as he could understand he could see no difference, whether it went from the earth to the cloud or from the cloud to the earth, in the effects produced. As to thunderbolts, he remembered many years ago seeing an object which he was told was a thunderbolt. It was a small ball which had been broken open, and had a beautiful crystalline structure inside. With the knowledge which he had acquired since, he imagined that if that was a thunderbolt, it would be formed simply by the sudden condensation of metallic vapour held in suspension in the atmosphere—supposing that it was metallic vapour. If, from disturbance in the atmosphere, such a bolt fell it would kill any man it struck, and injure a building, but that was very different from the damage done by lightning.

Professor LEBOUR said, the thunderbolts alluded to by Mr. Walker were undoubtedly lumps of iron pyrites, and were common in the South of England. They certainly had not come from above, but from the chalk and the green sand, and other formations.

Professor HERSCHEL said, he did not think a discussion had ever been raised in the North as to whether lightning went up or down. The question of its going up or down would not affect the danger of its action; but the question of what road it took was a far more important point. This subject had already been placed before the Institute at considerable length in papers contained in Vol. XXX., where there was a carefully described instance of the lightning's course in a pit; and therefore they could not doubt that it did enter the pit, and ramify about the wagonways

for the long distance of 800 yards, and always continuing to have great intensity and tension. So far from diffusing itself in the coal, as they hoped and wished it would without risk, it had been attended with reports and flashes which could not but be attended with risk in a fiery mine. The course which the lightning pursued in this case might certainly be too difficult for them to enter upon without much more full details as to the metallic parts of the connection between the point of the stroke of the lightning above ground, and where it was received and perceived below ground. Such probabilities as that the grease would affect the direction the lightning would take, could not possibly be entertained. Mr. Walker spoke about the tension of lightning, and instanced that of 10,000 cells as below the mark. If 50,000 cells were necessary to produce a spark a quarter of an inch long, what would be necessary when they had lightning flashes of a mile or more long? They could not describe the tension by thousands of thousands of cells; and grease would present no obstacle to such an electric force. He believed the evidence brought before the Institute on former occasions of lightning strokes in mines, and those which had now been freshly introduced, all pointed to this: that the stroke of the lightning must be warded off, and not guided into the mine in any manner. Mr. Walker was right in saying that a good lightning conductor should be provided about all the prominent parts of a colliery, and have a good earth connection. In page 43, Vol. XXX. of the Proceedings of the Institute, Mr. Heaviside wrote a letter in which he gave three instances of earth being unsuitable for electrical purposes—at the Ballast Hill, North Shields, at Throckley, and at West Stanley, when they were unable to find earth for the electric telegraph wires. At the North Shields Ballast Hill the return wire had to be taken down to the River Tyne. There was no doubt they would not get a good earth for a lightning conductor at all collieries; but at most collieries there was a stream of running water, to which the conductor must be taken, no matter how distant. This was really the point in the matter of protecting mines. It was unnecessary to enter into elaborate details what route the lightning took on one occasion or another. They could not foretell or foresee what direction it would take. The supposed probability that it would repeat its stroke a second time at the same place was perhaps ideal. The lightning did not strike the chimney on the previous occasion. A long iron rope leading into the sump was a suitable channel for the lightning to take, but whether it would take the same channel another time one could not say.

Colonel PARNELL said that the matter required careful study. There had been a good deal of controversial matter mentioned which had no connection with this incident at all, and he hardly thought this the time or place to enter into these matters. He thought Mr. White's paper very interesting, and he hoped they would soon be able to obtain some light as to the best means of protecting collieries in regard to lightning strokes.

Mr. MASSINGHAM said, he had been courteously invited to attend the meeting, not as a scientist, but as a practical man. He had advanced the theory, that after a chimney or other building had once been struck by lightning, that it had a greater affinity for the electric fluid than it had before, and was thereby rendered more liable to be struck again. He had no scientific authority for this assertion, although he had carefully searched all the books that he could find bearing upon the subject, but could not find that this particular fact had been noticed at all. The suggestion was based solely on his own personal observation and knowledge of the fact, that numerous cases of spires, chimneys, etc., had been struck by lightning several times over (although previous to the first stroke they had stood for years unharmed), whilst others in the immediate vicinity had escaped uninjured, and he thought that there must be some particular reason for this. He knew that this had been the case in a great many local instances, and no doubt there were hundreds of similar cases which he knew nothing of. He was inclined to think that when a building or chimney had been struck by lightning it remained charged with electricity, the same as a piece of magnetised iron, for an indefinite time, and being in this charged state, the chimney or building would have a greater affinity for lightning than it had before, and be more liable to be struck again.

Professor MERIVALE said, that as to a place once struck being struck again by lightning, he supposed it would not be a matter of wonder; because the conditions which would make the place liable to be struck once, would make it liable to be struck again.

Mr. WALKER said, he could fall in with the view of the last speaker, and not with those of Mr. Massingham, that the chimney remained in a charged condition. An object was struck because the meterological and electrical conditions were favourable to discharge by that path; and if these conditions remained the same, the object might be again struck.

Mr. MASSINGHAM said, he could not agree to the remarks of Professor Merivale, for he had known a chimney built on a certain spot

of earth fifty years ago, on a certain spot which would presumably remain the same during the whole fifty years. For the first forty years the chimney was not visited by lightning, but in its fortieth year it received a stroke, and in the ensuing ten years several other strokes. What is to be inferred from this? Did the conditions remain the same as they always were, or were they altered? If altered, in what way? May not the building and its surroundings have become charged as suggested? He did not pretend to be able to solve this question, but certainly considered that such cases as this, of which he had numerous instances, will go a long way to prove, at least, the consistency of the theory advanced. Mr. Walker said that he could fall in with the views of the last speaker, but would not admit "that the chimney remained in a charged condition," but as he did not give satisfactory reasons for saying so, he (Mr. Massingham) could not accept his opinion as final or conclusive. Professor John Murray, F.S.A., F.L.S., F.H.S., F.G.S., &c., in his work entitled, "A Treatise on Atmospherical Electricity, Lightning Rods, and Paragrêles," said:—"Once struck, we should presume that the same spot is always liable to a revisit, as there are several instances of buildings in this country having been similarly visited." This exactly coincided with his own observations and experience, and, coming from so eminent a scientist, he submitted that it is a theory that should receive a full and free investigation, as it must be a point of great importance, more particularly in the protection of collieries and their surroundings. Mr. Walker also said, that in the case of the West Thornley pit, if the rope and the pulley had been electrically connected, the lightning would not have gone down the pit! Where would it have gone? He was of opinion that whilst the rope was running over the pulley, both were electrically connected, the bright parts of the rope coming in contact with the bright parts of the inside of the pulley, forming a perfect electrical connection, and yet the stroke went down the pit. There is but one way of preventing lightning strokes from going down pit shafts, and that is, to have properly constructed lightning conductors erected considerably higher, and independent of the head gearing of the shaft, and carried to a perfect and good earth contact; indeed this, the earth contact, is the principal part of a lightning conductor, and the neglect or ignorance of this fact, is the most frequent cause of their failure. It still remains to solve the question or theory, as to whether a place having been once struck is thereby rendered more liable to be struck again; and as this very important point in the subject of lightning strokes,

appears hitherto to have received very little attention at the hands of our great scientists, it could not fail to be both useful and instructive, if it were more specially considered by experts.

The PRESIDENT proposed a vote of thanks to Mr. White for his paper, and said that it showed one of the many dangers to which coal-mining was liable; and the use of such an Institute as this was to bring these matters before the members for discussion.

The motion was agreed to.

The following communication from Mr. F. H. Pearce, containing calculations and tables on ventilation, was taken as read, and ordered to to be printed:—

VENTILATION TABLES.

By F. H. PEARCE.

These tables were calculated out in a simple way some years ago, and as they have often proved to be very useful they are now submitted to the members of the Institute.

TABLE I.—THE RELATIVE VENTILATING POWER OF AIR-WAYS.

This table shows the relative ventilating or discharging power of air-ways, that is to say, the relative quantities of air that will pass through air-ways in a given time; the air-ways being of the same length and subject to the same ventilating pressure.

The relative ventilating or discharging power of air-ways is found by multiplying the area of the air-way by the relative velocity of the air in such air-way. The relative velocity is calculated from the established law—"That the velocity is in inverse proportion to the square root of the frictional resistance." The frictional resistance for any form of air-way is represented by the perimeter of the air-way divided by the area of the air-way.

$$\frac{\text{Perimeter}}{\text{Area}} = \text{frictional resistance.}$$

But as the velocity is in inverse proportion to the square root of the frictional resistance the relative velocity is found thus—

$$\sqrt{\frac{\text{Area}}{\text{Perimeter}}} = \text{relative velocity.}$$

And the relative ventilating power of any form of air-way may be represented thus—

$$\text{Area} \times \sqrt{\frac{\text{Area}}{\text{Perimeter}}} = \text{relative ventilating power.}$$

In dealing with or comparing square air-ways only, where the perimeter is always four times the square root of the area, the above formula may be simplified and the relative velocity can be represented by the square root of the side of the air-way.

Thus, if a = side of air-way,

then a^2 = area of air-way.

and $\sqrt{a}$ = relative velocity.

Therefore $a^2 \times \sqrt{a}$ = relative ventilating power.

An air-way 1 foot square will have a ventilating power of 1.

Thus $1^2 \times \sqrt{1} = 1$ relative ventilating power.

An air-way 4 feet square will have a ventilating power of 32.

Thus $4^2 \times \sqrt{4} = 32$ relative ventilating power.

The relative ventilating power of circular shafts of the same depth and subject to the same ventilating pressure is found thus—

$$\text{Area} \times \sqrt{\text{diameter}} = \text{relative ventilating power.}$$

TABLE II.—RELATIVE VENTILATING POWER OF LONG AND SHORT AIR-WAYS.

In this table the ventilating power of an air-way 1760 yards, or one mile long, is taken as one or unity, and the relative ventilating powers for other lengths of air-ways of the same area are found thus—

$$\sqrt{\frac{1760}{\text{Length of air-way in yards}}} = \text{relative ventilating power.}$$

An air-way of 440 yards long is passing 5000 cubic feet of air per minute; required the quantity of air that will pass each of two air-ways of respectively 110 and 880 yards long, all the air-ways being of the same size and subject to the same ventilating pressure.

By the table, No. 1 air-way, ventilating power = 2.
" 2 " " = 4.
" 3 " " = 1·41421.

Then to find the quantity of air for the air-way, 110 yards long, or No. 2 air-way—

$$\frac{5000 \times 4}{2} = 10000 \text{ cubic feet per minute,}$$

and for No. 3 air-way, 880 yards long—

$$\frac{5000 \times 1{\cdot}41421}{2} = 3535 \text{ cubic feet per minute.}$$

TABLE III.—QUANTITIES OF AIR DISCHARGED PER MINUTE BY SQUARE AIR-WAYS ONE MILE LONG.

This table is based on the co-efficient of friction adopted by the late Mr. Atkinson for the air-ways of a mine. The water-gauge pressure given in the tables is the pressure required to overcome the frictional resistance.

This table was calculated out as follows:—One calculation was made by the late Mr. Atkinson's formula for an air-way one foot square and one mile long, with a ventilating pressure of one-half inch of water-gauge, which gives 75·32 cubic feet per minute for this air-way. Then, by using Table No. 1, the quantities for the different sized air-ways are found. Then, having thus found the quantities for one-half inch water-gauge pressure, the remaining columns of the table for different water-gauge pressures are found by using Table No. 6 of square roots.

By using the multipliers in Table II., the quantity of air for any length of square air-ways may be found.

TABLE IV.—SHOWING THE VELOCITY AND PRESSURE OF AIR DUE COLUMNS OF AIR UP TO 384 FEET IN HEIGHT.

In this table a column of air 64 feet in height is taken as being equal to a water-gauge pressure of 1 inch, so that $\frac{1}{64}$ part of an inch water-gauge pressure is equal to an air column of 1 foot, and $\frac{1}{8}$ of an inch water-gauge pressure is equal to an air column of 8 feet. This rule is easy to remember and agrees very nearly with the weight of dry air at 32 degrees Fahrenheit, and 30 inches barometrical pressure.

The theoretical velocity in the table is calculated from the following formula—

$$\sqrt{\text{Height of air column in feet}} \times 481{\cdot}2 = \text{the velocity of air in feet per minute.}$$

TABLE V.—VENTILATING PRESSURE OBTAINABLE BY FURNACE SHAFTS.

This table is arranged for shafts 100 yards deep, with an average temperature of 40 degrees Fahrenheit in the downcast shaft. Air at a temperature of 40 degrees expands $\frac{1}{500}$ part for an increase of temperature of 1 degree, so that for an increase of temperature of 5 degrees it will expand $\frac{5}{500}$ parts, or $\frac{1}{100}$ part, which is an expansion of 1 per cent. for every 5 degrees of increased temperature.

In the table a column of air 100 yards in height, at 40 degrees Fahrenheit and 30 inches barometrical pressure, is taken as weighing 23·8554 lbs., or equal to a water-gauge pressure of 4·587577 inches.

The table is calculated as follows:—A furnace shaft 100 yards deep having an average temperature of 160 degrees, with an average temperature of 40 degrees in the downcast, will give a water-gauge pressure of ·887918 inches.

Thus $160 - 40 = 120$ degrees increase of temperature,

and $\frac{120}{5} = 24$ per cent. increase in volume of air by expansion,

then $4{\cdot}587577 - \left(4{\cdot}587577 \times \frac{100}{100 + 24}\right) = {\cdot}887918$ inches of water-gauge or ventilating pressure.

To use the table for any depth of shaft, multiply the ventilating pressure given in the table corresponding with the average temperature of furnace shaft by the depth of shaft in yards, and divide by 100.

A furnace shaft 400 yards deep, with an average temperature of 140 degrees, and an average temperature of 40 degrees in the downcast, will give a ventilating pressure of 3·0584 inches of water-gauge.

By the table 140 degrees gives ·7646 inches of water-gauge for a shaft 100 yards deep.

Then $\frac{{\cdot}7646 \times 400}{100} = 3{\cdot}0584$ inches of ventilating or water-gauge pressure for shaft 400 yards deep.

When the average temperature of downcast shaft is above 40 degrees.

A furnace shaft 300 yards deep, with an average temperature of 120 degrees, and with an average temperature of 50 degrees in the downcast shaft.

By table, 120 degrees =	·6328	inches water-gauge.	
and 50 degrees =	·0900	„	„
Difference ...	·5428	„	„

Then $\frac{{\cdot}5428 \times 300}{100} = 1{\cdot}6284$ inches of ventilating or water-gauge pressure for shaft 300 yards deep, with the average temperatures as stated.

TABLE VI.—SQUARE ROOTS OF WATER-GAUGE PRESSURES.

This is a table of square roots arranged for water-gauge pressures, the ordinary published tables of square roots not being arranged for this purpose.

Since this table was arranged some tables of this sort have been published, but they are not so extensive as the table now given.

TABLE I.—THE RELATIVE VENTILATING POWER OF DIFFERENT SIZED AIR-WAYS.

Square Air-Ways.			Circular Shafts.	
Side of Square.	Area of Square.	Ventilating Power.	Area of Circle for Diameter in First Column.	Ventilating Power.
Ft. In.	Feet.		Feet.	
1 0	1·	1·	·785400	·785400
1 1½	1·265625	1·342398	·994021	1·054319
1 3	1·5625	1·746928	1·227187	1·372037
1 4½	1·890625	2·216954	1·484896	1·741196
1 6	2·25	2·755676	1·767150	2·164308
1 7½	2·640625	3·366150	2·073946	2·643774
1 9	3·0625	4·051307	2·405287	3·181897
1 10½	3·515625	4·813968	2·761171	3·780890
2 0	4·	5·656854	3·141600	4·442893
2 1½	4·515625	6·582598	3·546571	5·169972
2 3	5·0625	7·593750	3·976087	5·964131
2 4½	5·640625	8·692787	4·430146	6·827315
2 6	6·25	9·882118	4·908750	7·761415
2 7½	6·890625	11·164088	5·411896	8·768275
2 9	7·5625	12·540988	5·939587	9·849692
2 10½	8·265625	14·015049	6·491821	11·007419
3 0	9·	15·588457	7·068600	12·243174
3 1½	9·765625	17·263349	7·669921	13·558634
3 3	10·5625	19·041818	8·295787	14·955444
3 4½	11·390625	20·925914	8·946196	16·435213
3 6	12·25	22·917652	9·621150	17·999524
3 7½	13·140625	25·019005	10·320646	19·649927
3 9	14·0625	27·231914	11·044687	21·387945
3 10½	15·015625	29·558287	11·793271	23·215079
4 0	16·	32·	12·566400	25·132800
4 1½	17·015625	34·558898	13·364071	27·142558
4 3	18·0625	37·236798	14·186287	29·245781
4 4½	19·140625	40·035490	15·033046	31·443874
4 6	20·25	42·956737	15·904350	33·738221
4 7½	21·390625	46·002728	16·800196	36·130543
4 9	22·5625	49·173828	17·720587	38·621125
4 10½	23·765625	52·473079	18·665521	41·212356
5 0	25·	55·901700	19·635000	43·855195
5 1½	26·265625	59·461338	20·629021	46·700935
5 3	27·5625	63·153621	21·647587	49·600854
5 4½	28·890625	66·980158	22·690696	52·606216
5 6	30·25	70·942538	23·758350	55·718269
5 7½	31·640625	75·042332	24·850546	58·938248
5 9	33·0625	79·281089	25 967287	62·267367
5 10½	34·515625	83·660350	27·108571	65·706839
6 0	36·	88·181629	28·274400	69·257851
6 1½	37·515625	92·846435	29·464771	72·921590
6 3	39·0625	97·656250	30·679687	76·699219
6 4½	40·640625	102·612548	31·919146	80·591895
6 6	42·25	107·716787	33·183150	84·600765
6 7½	43·890625	112·970410	34·471696	88·726960
6 9	45·5625	118·374847	35·784787	92·971605
6 10½	47·265625	123·931514	37·122421	97·335811
7 0	49·	129·641814	38·484600	101·820681
7 1½	50·765625	135·507138	39·871321	106·427306
7 3	52·5625	141·578862	41·282587	111·196038
7 4½	54·390625	147·708355	42·718396	116·010142
7 6	56·25	154·046969	44·178750	120·988489
7 7½	58·140625	160·546048	45·663646	126·092866
7 9	60·0625	167·206925	47·173087	131·324319
7 10½	62·015625	174·030916	48·707071	136·683881

TABLE I.—CONTINUED.—THE RELATIVE VENTILATING POWER OF DIFFERENT SIZED AIR-WAYS.

Square Air-ways.			Circular Shafts.	
Side of Square.	Area of Square.	Ventilating Power.	Area of Circle for Diameter in First Column.	Ventilating Power.
Ft. In.	Feet.		Feet.	
8 0	64·	181·019334	50·265600	142·172585
8 1½	66·015625	188·173483	51·848671	147·791454
8 3	68·0625	195·494646	53·456287	153·541495
8 4½	70·140625	202·984109	55·088446	159·423719
8 6	72·25	210·643137	56·745150	165·439120
8 7½	74·390625	218·472993	58·426396	171·588689
8 9	76·5625	226·474930	60·132187	177·873410
8 10½	78·765625	234·650187	61·862521	184·294257
9 0	81·	243·	63·617400	190·852200
9 1½	83·265625	251·525594	65·396821	197·548202
9 3	85·5625	260·228183	67·200787	204·383215
9 4½	87·890625	269·108981	69·029296	211·358194
9 6	90·25	278·169182	70·882350	218·474076
9 7½	92·640625	287·409981	72·759946	225·731800
9 9	95·0625	296·832561	74·662087	233·132293
9 10½	97·515625	306·438100	76·588771	240·676484
10 0	100·	316·227770	78·540000	248·365291
10 3	105·0625	336·364118	82·516087	264·180378
10 6	110·25	357·250831	86·590350	280·584803
10 9	115·5625	378·896993	90·762787	297·565698
11 0	121·	401·311601	95·033400	315·190131
11 3	126·5625	424·503528	99·402187	333·405071
11 6	132·25	448·481570	103·869150	352·237425
11 9	138·0625	473·254357	108·434287	371·693972
12 0	144·	498·830630	113·097600	391·781577
12 3	150·0625	525·218750	117·859087	412·506806
12 6	156·25	552·427173	122·718750	433·876302
12 9	162·5625	580·464227	127·676587	455·896604
13 0	169·	609·338171	132·732600	478·574200
13 3	175·5625	639·057147	137·886787	501·915483
13 6	182·25	669·629258	143·139150	525·926820
13 9	189·0625	701·062514	148·489687	550·614498
14 0	196·	733·364850	153·938400	575·984753
14 3	203·0625	766·544124	159·485287	602·043755
14 6	210·25	800·608147	165·130350	628·797639
14 9	217·5625	835·564631	170·873587	656·252461
15 0	225·	871·421242	176·715000	684·414243
15 3	232·5625	908·185598	182·654587	713·288969
15 6	240·25	945·865197	188·692350	742·882526
15 9	248·0625	984·467523	194·828287	773·200793
16 0	256·	1024·	201·062400	804·249600
16 3	264·0625	1064·469962	207·394687	836·034708
16 6	272·25	1105·884727	213·825150	868·561865
16 9	280·5625	1148·251522	220·353787	901·836745
17 0	289·	1191·577527	226·980600	935·864990
17 3	297·5625	1235·869887	233·705587	970·652209
17 6	306·25	1281·135665	240·528750	1006·203951
17 9	315·0625	1327·38191	247·450087	1042·525753
18 0	324·	1374·615554	254·469600	1079·623057
18 3	333·0625	1422·843616	261·587287	1117·501376
18 6	342·25	1472·087310	268·803150	1156·177373
18 9	351·5625	1522·310273	276·117187	1195·622488
19 0	361·	1573·562504	283·529400	1235·875991
19 3	370·5625	1625·836373	291·039787	1276·931887
19 6	380·25	1679·138534	298·648350	1318·795405
19 9	390·0625	1733·475664	306·355087	1361·471787
20 0	400·	1788·854400	314·160000	1404·966246

TABLE II.—THE RELATIVE VENTILATING POWER OF LONG AND SHORT AIR-WAYS.

Length. Miles.	Length. Yards.	Ventilating Power.	Length. Miles.	Length. Yards.	Ventilating Power.
...	100	4·19524	2	3520	·70711
1/16	110	4·		3600	·69914
	200	2·96648		3700	·68971
1/8	220	2·82843		3800	·68051
	300	2·42074		3900	·67179
	400	2·09762	2¼	3960	·66663
¼	440	2·		4000	·66332
	500	1·87617		4100	·65513
	600	1·71172		4200	·64730
	700	1·58430		4300	·63977
	800	1·48324	2½	4400	·63246
½	880	1·41421		4500	·62538
	900	1·39642		4600	·61855
	1000	1·32665		4700	·61188
	1100	1·26491		4800	·60548
	1200	1·20830	2¾	4840	·60299
	1300	1·16190		4900	·59925
¾	1320	1·15326		5000	·59330
	1400	1·11804		5100	·58745
	1500	1·08167		5200	·58172
	1600	1·04881	3	5280	·58060
	1700	1·01489		5300	·57619
1	1760	1·		5400	·57088
	1800	·98879		5500	·56569
	1900	·96245		5600	·56054
	2000	·93808		5700	·55561
	2100	·91543	3¼	5720	·55471
1¼	2200	·89443		5800	·55082
	2300	·87476		5900	·54617
	2400	·85633		6000	·54157
	2500	·83905		6100	·53759
	2600	·82274	3½	6160	·53451
1½	2640	·81646		6200	·53273
	2700	·80734		6300	·52849
	2800	·79278		6400	·52440
	2900	·77904		6500	·52029
	3000	·76590	3¾	6600	·51633
1¾	3080	·75591		6700	·51245
	3100	·75346		6800	·50872
	3200	·74162		6900	·50498
	3300	·73027		7000	·50140
	3400	·71944	4	7040	·50000
	3500	·70908			

TABLE III.—QUANTITIES OF AIR DISCHARGED PER MINUTE BY SQUARE AIR-WAYS ONE MILE LONG.

Side of Square Air-way.		Area of Square Air-way.	Water-Gauge Pressure in Fractional and Decimal parts of an Inch.									
			1/64 ·015625	1/32 ·03125	1/16 ·0625	1/8 ·125	3/16 ·1875	1/4 ·25	5/16 ·3125	3/8 ·375	7/16 ·4375	1/2 ·5
Ft.	In.	Square Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.
1	0	1·	13	18	26	37	46	53	59	65	70	75
1	3	1·5625	23	33	46	66	80	93	104	114	123	132
1	6	2·25	36	52	73	104	127	147	164	179	194	208
1	9	3·0625	54	76	108	152	186	216	241	264	285	305
2	0	4·	75	106	150	213	261	301	337	369	398	426
2	3	5·0625	101	143	202	286	350	404	452	495	535	572
2	6	6·25	131	186	263	372	455	526	588	644	696	744
2	9	7·5625	167	236	334	472	578	668	747	818	883	945
3	0	9·	207	293	415	587	719	830	928	1017	1098	1174
3	3	10·5625	253	358	507	717	878	1014	1134	1242	1341	1434
3	6	12·25	305	431	610	863	1057	1220	1364	1495	1614	1726
3	9	14·0625	362	512	725	1025	1256	1450	1621	1776	1918	2051
4	0	16·	426	602	852	1205	1478	1704	1905	2087	2254	2410
4	3	18·0625	495	701	991	1402	1767	1983	2217	2429	2623	2805
4	6	20·25	572	809	1144	1618	1981	2288	2558	2802	3026	3236
4	9	22·5625	654	926	1309	1852	2268	2619	2928	3207	3464	3704
5	0	25·	744	1152	1488	2105	2578	2977	3328	3646	3938	4211
5	3	27·5625	840	1189	1681	2378	2913	2363	3760	4119	4449	4757
5	6	30·25	944	1335	1889	2671	3272	3778	4224	4627	5048	5343
5	9	33·0625	1050	1492	2111	2985	3656	4222	4721	5171	5586	5971
6	0	36·	1174	1660	2348	3321	4067	4696	5250	5752	6213	6642
6	3	39·0625	1300	1838	2600	3677	4504	5201	5815	6370	6880	7355
6	6	42·25	1434	2028	2868	4056	4968	5737	6414	7026	7589	8113
6	9	45·5625	1588	2229	3177	4458	5460	6354	7048	7721	8340	8916
7	0	49·	1726	2441	3452	4882	5979	6904	7719	8456	9134	9765
7	3	52·5625	1885	2666	3770	5332	6530	7540	8433	9235	9975	10664
7	6	56·25	2051	2900	4102	5801	7105	8204	9173	10048	10853	11603
7	9	60·0625	2226	3148	4452	6297	7712	8905	9956	10906	11780	12594
8	0	64·	2410	3408	4820	6817	8349	9641	10779	11807	12754	13634
8	3	68·0625	2603	3681	5206	7362	9017	10412	11641	12752	13774	14725
8	6	72·25	2804	3966	5609	7933	9715	11218	12543	13740	14841	15866
8	9	76·5625	3015	4264	6031	8529	10446	12062	13485	14722	15957	17058
9	0	81·	3235	4575	6471	9151	11208	12942	14469	15850	17120	18303
9	3	85·5625	3464	4900	6929	9800	12002	13859	15545	16974	18334	19600
9	6	90·25	3703	5238	7407	10476	12830	14815	16564	18144	19598	20952
9	9	95·0625	3952	5589	7905	11178	13691	15809	17675	19354	20913	22357
10	0	100·	4210	5954	8421	11909	14585	16842	18830	20627	22273	23818
10	6	110·25	4756	6727	9513	13454	16478	19027	21272	23303	25170	26908
11	0	121·	5343	7556	10686	15113	18510	21373	23896	26177	28274	30227
11	6	132·25	5971	8445	11942	16890	20685	23885	26705	29254	31598	33780
12	0	144·	6641	9393	13283	18786	23008	26567	29698	32538	35145	37572
12	6	156·25	7355	10402	14711	20804	25476	29422	32894	36034	38921	41609
13	0	169·	8113	11473	16226	22947	28105	32453	36283	39746	42931	45895
13	6	182·25	8903	12609	17807	25218	30886	35614	39873	43679	47160	50436
14	0	196·	9764	13809	19529	27618	33825	39058	43669	47837	51670	55237
14	6	210·25	10659	15075	21319	30151	36927	42639	47673	52223	56407	60302
15	0	225·	11602	16408	23205	32817	40193	46411	51889	56342	61391	65635
15	6	240·25	12594	17810	25188	35621	43627	50376	56322	61698	65941	71243
16	0	256·	13634	19282	27268	38564	47230	54537	60975	66794	72146	77128

TABLE III.—CONTINUED.—QUANTITIES OF AIR DISCHARGED PER MINUTE BY SQUARE AIR-WAYS ONE MILE LONG.

Side of Square Air-way.		Area of Square Air-way.	Water-Gauge Pressure in Fractional and Decimal parts of an Inch.									
			9/16 ·5625	5/8 ·625	11/16 ·6875	3/4 ·75	13/16 ·8125	7/8 ·875	15/16 ·9375	1	1 1/8 1·125	1 1/4 1·25
Ft.	In	Square Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.
1	0	1·	79	84	88	92	96	99	103	107	111	119
1	3	1·5625	139	127	154	161	167	174	180	186	198	208
1	6	2·25	220	232	243	254	264	274	284	294	312	328
1	9	3·0625	324	341	358	373	389	403	416	432	456	482
2	0	4·	451	476	499	522	543	563	533	603	639	674
2	3	5·0625	606	639	670	700	729	756	783	809	858	904
2	6	6·25	789	832	873	911	949	984	1019	1053	1116	1177
2	9	7·5625	1002	1056	1107	1157	1204	1249	1293	1336	1416	1494
3	0	9·	1245	1312	1377	1438	1496	1554	1607	1660	1761	1856
3	3	10·5625	1521	1603	1682	1756	1828	1897	1964	2028	2151	2268
3	6	12·25	1837	1930	2024	2114	2200	2283	2363	2441	2589	2729
3	9	14·0625	2175	2293	2405	2512	2614	2713	2808	2901	3075	3243
4	0	16·	2556	2694	2826	2957	3072	3188	3300	3409	3615	3811
4	3	18·0625	2974	3135	3288	3435	3575	3710	3840	3966	4206	4435
4	6	20·25	3432	3617	3794	3962	4124	4330	4430	4576	4854	5116
4	9	22·5625	3928	4141	4343	4536	4721	4899	5071	5238	5556	5856
5	0	25·	4465	4707	4937	5157	5367	5570	5765	5955	6315	6657
5	3	27·5625	5044	5318	5578	5826	6063	6292	6513	6727	7134	7521
5	6	30·25	5667	5974	6265	6544	6811	7068	7311	7557	8013	8448
5	9	33·0625	6333	6676	7002	7313	7611	7899	8176	8445	8955	9442
6	0	36·	7044	7426	7788	8134	8466	8786	9094	9393	9963	10501
6	3	39·0625	7801	8224	8625	9008	9376	9730	10072	10402	11031	11630
6	6	42·25	8605	9071	9513	9936	10342	10733	11109	11474	12168	12828
6	9	45·5625	9532	9968	10455	10920	11365	11794	12208	12609	13374	14097
7	0	49·	10356	10917	11450	11959	12447	12917	13370	13809	14646	15439
7	3	52·5625	11310	11922	12504	13060	13593	14107	14602	15081	15996	16866
7	6	56·25	12306	12972	13605	14210	14791	15349	15888	16409	17403	18346
7	9	60·0625	13357	14081	14768	15424	16054	16661	17345	17811	18891	19913
8	0	64·	14461	15243	15987	16698	17380	18036	18669	19282	20451	21558
8	3	68·0625	15618	16463	17267	18034	18770	19479	20161	20824	22086	23282
8	6	72·25	16877	17738	18604	19431	20225	21988	21725	22437	23799	25086
8	9	76·5625	18093	19071	20002	20892	21745	22565	23357	24124	25587	26971
9	0	81·	19413	20463	21462	22416	23331	24212	25062	25884	27454	28939
9	3	85·5625	20788	21914	22988	24005	24985	25929	26844	27719	29400	31091
9	6	90·25	22222	23424	24568	25660	26708	27716	28689	29630	31428	33128
9	9	95·0625	23713	24997	26217	27382	28500	29576	30614	31618	33535	35350
10	0	100·	25263	26629	27929	29171	30362	31508	32614	33684	35727	37660
10	6	110·25	28540	30084	31552	32956	34300	35596	36845	38054	40362	42545
11	0	121·	32059	33794	35444	37020	39042	39986	41389	42747	45340	47793
11	6	132·25	35829	37767	39609	41371	43061	44686	46254	47771	50670	53410
12	0	144·	39850	42006	44057	46016	47889	49703	51447	53135	56358	59396
12	6	156·25	44133	46520	48798	50952	53091	55043	56975	58844	62413	65789
13	0	169·	48678	51312	53817	56210	58505	60714	62844	64906	68842	72567
13	6	182·25	53421	56389	59142	61772	64294	66721	69063	71328	75654	79747
14	0	196·	58587	61757	64771	67651	70408	73071	75636	78117	82855	87338
14	6	210·25	63958	67419	70710	73854	76870	79771	82571	85279	90453	95346
15	0	225·	69616	73383	76964	80386	83669	86727	89875	92822	98452	103779
15	6	240·25	75564	79651	83539	87254	90812	94245	97553	100752	106864	112644
16	0	256·	81805	86231	90440	94461	98319	102030	105611	109075	115692	121950

TABLE III.—CONTINUED.—QUANTITIES OF AIR DISCHARGED PER MINUTE BY SQUARE AIR-WAYS ONE MILE LONG.

Side of Square Air-way.		Area of Square Air-way.	Water-Gauge Pressure in Inches.									
			1½	1¾	2	2¼	2½	2¾	3	3¼	3½	3¾
Ft.	In	Square Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.	Cubic Ft.
1	0	1·	130	141	151	159	168	176	184	192	199	206
1	3	1·5625	228	246	264	279	294	309	322	335	348	360
1	6	2·25	359	388	416	441	464	487	508	529	549	568
1	9	3·0625	529	571	610	648	682	716	747	778	807	833
2	0	4·	738	797	852	903	953	999	1044	1086	1127	1067
2	3	5·0625	991	1070	1144	1212	1279	1341	1401	1458	1513	1566
2	6	6·25	1289	1392	1488	1578	1664	1746	1823	1898	1969	2038
2	9	7·5625	1636	1767	1890	2004	2112	2215	2314	2408	2499	2587
3	0	9·	2034	2197	2348	2490	2625	2754	2876	2993	3108	3215
3	3	10·5625	2484	2683	2868	3042	3207	3364	3513	3657	3794	3928
3	6	12·25	2990	3229	3452	3675	3860	4048	4228	4401	4567	4727
3	9	14·0625	3553	3837	4102	4350	4586	4810	5024	5229	5427	5617
4	0	16·	4175	4509	4820	5112	5389	5652	5904	6145	6377	6601
4	3	18·0625	4858	5247	5610	5949	6271	6577	6870	7151	7420	7681
4	6	20·25	5604	6053	6472	6864	7235	7588	7925	8249	8660	8861
4	9	22·5625	6415	6929	7408	7857	8282	8686	9072	9443	9799	10143
5	0	25·	7293	7877	8422	8931	9415	9875	10314	10735	11140	11531
5	3	27·5625	8239	8899	9514	10089	10636	11156	11652	12127	12585	13027
5	6	30·25	9255	10097	10686	11334	11948	12531	13089	13623	14136	14633
5	9	33·0625	10343	11172	11942	12666	13352	14004	14627	15222	15799	16353
6	0	36·	11504	12426	13284	14088	14852	15577	16269	16933	17573	18189
6	3	39·0625	12740	13761	14710	15603	16448	17250	18017	18753	19461	20144
6	6	42·25	14053	15178	16226	17211	18142	19027	19873	20685	21466	22219
6	9	45·5625	15443	16680	17832	19062	19937	20910	21840	22731	23589	24417
7	0	49·	16913	18268	19530	20712	21834	22900	23918	24895	25835	26741
7	3	52·5625	18470	19950	21328	22620	23845	25009	26121	27187	28214	29204
7	6	56·25	20097	21707	23206	24612	25945	27211	28421	29582	30698	31776
7	9	60·0625	21813	23561	25188	26715	28162	29536	30849	32109	33321	34690
8	0	64·	23615	25508	27268	28923	30487	31975	33397	34761	36073	37339
8	3	68·0625	25504	27548	29450	31236	32926	34335	36068	37541	38958	40323
8	6	72·25	27480	29682	31732	33654	35477	37208	38863	40450	41977	43450
8	9	76·5625	29545	31913	34116	36186	38143	40005	41784	43490	45131	46715
9	0	81·	31701	34241	36606	38826	40926	42924	44832	46663	48425	50124
9	3	85·5625	33949	36669	39200	41577	43828	45977	48011	49971	51858	53688
9	6	90·25	36289	39197	41904	44445	46849	49136	51321	53417	55433	57378
9	9	95·0625	38708	41827	44714	47427	49994	52434	54764	57000	59152	61229
10	0	100·	41254	44547	47636	50526	53259	55859	58343	60725	63017	65229
10	6	110·25	46606	50341	53816	57081	60168	63105	65912	68600	71192	73691
11	0	121·	52354	56549	60454	64119	67589	70888	74040	78084	79973	82779
11	6	132·25	58508	63196	67560	71655	75534	79219	82743	86122	89372	92509
12	0	144·	65076	70291	75144	79701	84013	88114	92032	95779	99406	102895
12	6	156·25	72069	77843	83218	88266	93040	97581	101920	106182	110087	113950
13	0	169·	79493	85862	91790	97356	102625	107634	112420	117011	121428	125689
13	6	182·25	87359	94320	100872	106842	112779	118284	123544	128588	133442	138126
14	0	196·	95674	103340	110474	117174	123514	129542	135303	140817	146143	151273
14	6	210·25	104446	112814	120604	127917	134839	141420	147709	153740	159543	165143
15	0	225·	113684	122783	131270	139233	146766	153929	160773	167339	173455	179750
15	6	240·25	123396	131883	142486	151128	159303	167079	174508	181624	188490	195106
16	0	256·	133589	144293	154256	163611	172463	180881	188923	196638	204061	211223

TABLE III.—CONTINUED.—QUANTITIES OF AIR DISCHARGED PER MINUTE BY SQUARE AIR-WAYS ONE MILE LONG.

Side of Square Air-way.		Area of Square Air-way.	Water-Gauge Pressure in Inches.			
			4 ins.	4½ ins.	5 ins.	6 ins.
Ft.	In.	Square Feet.	Cubic Feet.	Cubic Feet.	Cubic Feet.	Cubic Feet.
1	0	1·0	214	226	238	260
1	3	1·5625	372	396	416	456
1	6	2·25	588	624	656	718
1	9	3·0625	864	913	964	1058
2	0	4·	1206	1278	1348	1476
2	3	5·0625	1618	1716	1808	1982
2	6	6·25	2106	2232	2354	2578
2	9	7·5625	2672	2835	2988	3272
3	0	9·	3320	3522	3712	4068
3	3	10·5625	4056	4302	4536	4968
3	6	12·25	4882	5178	5458	5980
3	9	14·0625	5802	6153	6486	7106
4	0	16·	6818	7230	7622	8350
4	3	18·0625	7932	8415	8870	9716
4	6	20·25	9152	9708	10232	11208
4	9	22·5625	10476	11112	11712	12830
5	0	25·	11910	12633	13314	14586
5	3	27·5625	13454	14271	15042	16478
5	6	30·25	15114	16029	16896	18510
5	9	33·0625	16890	17913	18884	20686
6	0	36·	18786	19926	21002	23008
6	3	39·0625	20804	22065	23260	25480
6	6	42·25	22948	24339	25656	28106
6	9	45·5625	25218	26748	28194	30886
7	0	49·	27618	29295	30878	33826
7	3	52·5625	30162	31994	33732	36940
7	6	56·25	32818	34809	36692	40194
7	9	60·0625	35622	37782	39826	43626
8	0	64·	38564	40902	43116	47230
8	3	68·0625	41648	44175	46564	51008
8	6	72·25	44874	47598	50172	54960
8	9	76·5625	48248	51174	53942	59090
9	0	81·	51768	54909	57878	63402
9	3	85·5625	55438	58800	62182	67898
9	6	90·25	59260	62856	66256	72578
9	9	95·0625	63236	67071	70700	77416
10	0	100·	67368	71454	75320	82508
10	6	110·25	76108	80724	85090	93212
11	0	121·	85494	90681	95586	104708
11	6	132·25	95542	101340	106820	117016
12	0	144·	106270	112716	118792	130152
12	6	156·25	117688	124827	131578	144138
13	0	169·	129812	137685	145134	158986
13	6	182·25	142656	151308	159494	174718
14	0	196·	156234	165711	174676	191348
14	6	210·25	170558	180906	190692	208892
15	0	225·	185644	196905	207558	227368
15	6	240·25	201504	213729	225288	246792
16	0	256·	218150	231384	243900	267178

TABLE IV.—SHOWING THE VELOCITY AND PRESSURE DUE TO COLUMNS OF AIR FROM 1 TO 384 FEET IN HEIGHT.

Height of Air Column.	Water Gauge Pressure.		Pressure per Square Foot.	Velocity of Air per Minute.
Feet.	Fractional Parts of an Inch.	Decimal Parts of an Inch.	Lbs.	Feet.
1	$\frac{1}{64}$	·015625	·08125	481
2	$\frac{1}{32}$	·031250	·16250	680
3	$\frac{3}{64}$	·046875	·24375	833
4	$\frac{1}{16}$	·062500	·32500	962
5	$\frac{5}{64}$	·078125	·40625	1076
6	$\frac{3}{32}$	·093750	·48750	1179
7	$\frac{7}{64}$	·109375	·56875	1273
8	$\frac{1}{8}$	·125000	·65000	1361
9	$\frac{9}{64}$	·140625	·73125	1444
10	$\frac{5}{32}$	·156250	·81250	1522
11	$\frac{11}{64}$	·171875	·89375	1596
12	$\frac{3}{16}$	·187500	·97500	1667
13	$\frac{13}{64}$	·203125	1·05625	1735
14	$\frac{7}{32}$	·218750	1·13750	1801
15	$\frac{15}{64}$	·234375	1·21875	1864
16	$\frac{1}{4}$	·250000	1·30000	1925
17	$\frac{17}{64}$	·265625	1·38125	1984
18	$\frac{9}{32}$	·281250	1·46250	2042
19	$\frac{19}{64}$	·296875	1·54375	2098
20	$\frac{5}{16}$	·312500	1·62500	2152
21	$\frac{21}{64}$	·328125	1·70625	2205
22	$\frac{11}{32}$	·343750	1·78750	2257
23	$\frac{23}{64}$	·359375	1·86875	2308
24	$\frac{3}{8}$	·375000	1·95000	2357
25	$\frac{25}{64}$	·390625	2·03125	2406
26	$\frac{13}{32}$	·406250	2·11250	2453
27	$\frac{27}{64}$	·421875	2·19375	2500
28	$\frac{7}{16}$	·437500	2·27500	2546
29	$\frac{29}{64}$	·453125	2·35625	2591
30	$\frac{15}{32}$	·468750	2·43750	2636
31	$\frac{31}{64}$	·484375	2·51875	2679
32	$\frac{1}{2}$	·500000	2·60000	2722
33	$\frac{33}{64}$	·515625	2·68125	2764
34	$\frac{17}{32}$	·531250	2·76250	2806
35	$\frac{35}{64}$	·546875	2·84375	2847
36	$\frac{9}{16}$	·562500	2·92500	2887
37	$\frac{37}{64}$	·578125	3·00625	2927
38	$\frac{19}{32}$	·593750	3·08750	2966
39	$\frac{39}{64}$	·609375	3·16875	3005
40	$\frac{5}{8}$	·625000	3·25000	3043
41	$\frac{41}{64}$	·640625	3·33125	3081
42	$\frac{21}{32}$	·656250	3·41250	3118
43	$\frac{43}{64}$	·671875	3·49375	3155
44	$\frac{11}{16}$	·687500	3·57500	3192
45	$\frac{45}{64}$	·703125	3·65625	3228
46	$\frac{23}{32}$	·718750	3·73750	3263
47	$\frac{47}{64}$	·734375	3·81875	3299
48	$\frac{3}{4}$	·750000	3·90000	3334
49	$\frac{49}{64}$	·765625	3·98125	3368
50	$\frac{25}{32}$	·781250	4·06250	3403
51	$\frac{51}{64}$	·796875	4·14375	3436
52	$\frac{13}{16}$	·812500	4·22500	3470
53	$\frac{53}{64}$	·828125	4·30625	3503
54	$\frac{27}{32}$	·843750	4·38750	3536
55	$\frac{55}{64}$	·859375	4·46875	3569

TABLE IV.—CONTINUED.—SHOWING THE VELOCITY AND PRESSURE DUE TO COLUMNS OF AIR FROM 1 TO 384 FEET IN HEIGHT.

Height of Air Column.	Water Gauge Pressure.		Pressure per Square Foot.	Velocity of Air per Minute.
Feet.	Fractional Parts of an Inch.	Decimal Parts of an Inch.	Lbs.	Feet.
56	$\frac{7}{8}$	·875000	4·55000	3601
57	$\frac{57}{64}$	·890625	4·63125	3633
58	$\frac{29}{32}$	·906250	4·71250	3665
59	$\frac{59}{64}$	·921875	4·79375	3696
60	$\frac{15}{16}$	·937500	4·87500	3728
61	$\frac{61}{64}$	·953125	4·95625	3758
62	$\frac{31}{32}$	·968750	5·03750	3789
63	$\frac{63}{64}$	·984375	5·11875	3819
	Inches.	Inches.		
64	1	1·	5·20000	3850
100	$1\frac{9}{16}$	1·562500	8·12500	4812
128	2	2·	10·40000	5444
192	3	3·	15·60000	6668
256	4	4·	20·80000	7700
320	5	5·	26·00000	8608
384	6	6·	31·20000	9430

TABLE V.—SHOWING THE VENTILATING PRESSURE IN INCHES OF WATER OBTAINABLE BY UPCAST SHAFTS.

CALCULATED FOR UPCAST SHAFTS 100 YARDS DEEP, WITH AN AVERAGE TEMPERATURE OF 40 DEGREES IN DOWNCAST SHAFT.

Average Temperature in Upcast Shafts.	Water Gauge Pressure.	Average Temperature in Upcast Shafts.	Water Gauge Pressure.	Average Temperature in Upcast Shafts.	Water Gauge Pressure.	Average Temperature in Upcast Shafts.	Water Gauge Pressure.
Deg. F.	Inches.	Deg. F.	Inches.	Deg. F.	Inches.	Deg. F.	Inches.
40	·0000	110	·5632	180	1·0035	245	1·3340
45	·0454	115	·5985	185	1·0304	250	1·3569
50	·0899	120	·6328	190	1·0587	255	1·3795
55	·1336	125	·6666	195	1·0856	260	1·4018
60	·1764	130	·6998	200	1·1121	265	1·4237
65	·2185	135	·7325	205	1·1383	270	1·4454
70	·2597	140	·7646	210	1·1640	290	1·5292
75	·3001	145	·7962	215	1·1894	300	1·5694
80	·3398	150	·8273	220	1·2144	350	1·7558
85	·3788	155	·8578	225	1·2390	400	1·9204
90	·4170	160	·8879	230	1·2632	450	2·0669
95	·4546	165	·9175	235	1·2872	500	2·1982
100	·4915	170	·9466	240	1·3107	540	2·2938
105	·5278	175	·9753				

TABLE VI.—SQUARE ROOTS OF WATER GAUGE PRESSURES.

Inches.	Square Roots.	Inches.	Square Roots.	Inches.	Square Roots.
0·05	·22360680	2·75	1·65831240	5·45	2·33452351
·10	·31622777	·80	1·67332005	·50	2·34520788
·15	·38729833	·85	1·68819430	·55	2·35584380
·20	·44721360	·90	1·70293864	·60	2·36643191
·25	·50000000	·95	1·71755640	·65	2·37697286
·30	·54772256	3·00	1·73205081	·70	2·38746728
·35	·59160798	·05	1·74642492	·75	2·39791576
·40	·63245553	·10	1·76068169	·80	2·40831891
·45	·67082039	·15	1·77482393	·85	2·41867732
·50	·70710678	·20	1·78885438	·90	2·42899156
·55	·74161985	·25	1·80277564	·95	2·43926218
·60	·77459667	·30	1·81659021	6·00	2·44948974
·65	·80622577	·35	1·83030052	·05	2·45967478
·70	·83666003	·40	1·84390889	·10	2·46981781
·75	·86602540	·45	1·85741756	·15	2·47991935
·80	·89442719	·50	1·87082869	·20	2·48997992
·85	·92195445	·55	1·88414437	·25	2·50000000
·90	·94868330	·60	1·89736660	·30	2·50998008
·95	·97467943	·65	1·91049732	·35	2·51992063
1·00	1·00000000	·70	1·92353841	·40	2·52982213
·05	1·02469508	·75	1·93649167	·45	2·53968502
·10	1·04880885	·80	1·94935887	·50	2·54950976
·15	1·07238053	·85	1·96214169	·55	2·55929678
·20	1·09544512	·90	1·97484177	·60	2·56904652
·25	1·11803399	·95	1·98746069	·65	2·57875939
·30	1·14017543	4·00	2·00000000	·70	2·58843582
·35	1·16189500	·05	2·01246118	·75	2·59807621
·40	1·18321596	·10	2·02484567	·80	2·60768096
·45	1·20415946	·15	2·03715488	·85	2·61725047
·50	1·22474489	·20	2·04939015	·90	2·62678511
·55	1·24498996	·25	2·06155281	·95	2·63628527
·60	1·26491106	·30	2·07364414	7·00	2·64575131
·65	1·28452326	·35	2·08566536	·25	2·69258240
·70	1·30384048	·40	2·09761770	·50	2·73861279
·75	1·32287566	·45	2·10950231	·75	2·78388218
·80	1·34164079	·50	2·12132034	8·00	2·82842712
·85	1·36014705	·55	2·13307290	·25	2·87228132
·90	1·37840488	·60	2·14476106	·50	2·91547595
·95	1·39642400	·65	2·15638587	·75	2·95803989
2·00	1·41421356	·70	2·16794834	9·00	3·00000000
·05	1·43178211	·75	2·17944947	·25	3·04138127
·10	1·44913767	·80	2·19089023	·50	3·08220700
·15	1·46628783	·85	2·20227155	·75	3·12249900
·20	1·48323970	·90	2·21359436	10·00	3·16227766
·25	1·50000000	·95	2·22485955	·25	3·20156212
·30	1·51657509	5·00	2·23606798	·50	3·24037035
·35	1·53297097	·05	2·24722051	·75	3·27871926
·40	1·54919334	·10	2·25831796	11·00	3·33166625
·45	1·56524758	·15	2·26936114	·25	3·35410196
·50	1·58113883	·20	2·28035085	·50	3·39116499
·55	1·59687194	·25	2·29128785	·75	3·42782730
·60	1·61245155	·30	2·30217289	12·00	3·46410162
·65	1·62788206	·35	2·31300670		
·70	1·64316767	·40	2·32379001		

Mr. Thomas E. Candler read the following paper on "A Description of Thompson's Patent Centrifugal Pulverizer":—

DESCRIPTION OF THOMPSON'S PATENT CENTRIFUGAL PULVERIZER; INCLUDING AN ACCOUNT OF ITS COMPARATIVE ADVANTAGES FOR CRUSHING AND PULVERIZING MINERAL ORES, COAL, AND OTHER SUBSTANCES.

By THOMAS E. CANDLER.

In mining operations, both at home and abroad, the great difficulty of selecting and fitting up at the mines efficient and suitable machinery, taxes to the utmost the skill of the mining engineer; and as the future of the mine depends entirely upon the successful and economical character of the machinery used in the treatment of the mineral worked, it is scarcely necessary for the writer to say how important it is that the most efficient and suitable machinery procurable should be used for this purpose.

The considerable sums spent by mining companies in the purchase of the machinery for the treatment of their minerals in most cases forms a large percentage of their working capital, and its wieldy and bulky nature often causes serious delay in its transport, more especially to those foreign mines in remote districts to which access is difficult.

In such cases the cost of transport is of necessity a very expensive item, increasing proportionately with the weight of the machinery selected for the work.

By the ordinary process of crushing with stamps a protracted and lengthened delay often occurs before a suitable position can be fixed upon for the erection of the mill, and when this is done the cost of excavating and making the required foundations is usually excessively high, and in cases where the property is extensive and has a mountainous and rugged character, additional sums have to be spent on the erection of tramways, inclines, shoots, etc., for conveying the ore found on the various parts of the property to the mill for treatment; this is an important consideration, as the transit of the mineral generally forms a material charge in the cost of working a mine.

For some length of time the mining profession generally, and more especially those who are, or have been, engaged in the extraction of the

precious metals, have pointed out the extent of the expenditure required for this purpose, and the numerous defects apparent in the present mode of crushing the ore by the ordinary application of stamping machinery; many suggestions have been made and numerous inventions patented with a view of both improving the efficiency of the work done and reducing to a minimum cost the necessary outlay for purchasing, erecting, and maintaining a mill capable of performing the work required for the successful treatment of the ores containing the precious metals.

Some of these inventions have been tried with more or less success, but the writer had recently the opportunity of viewing in operation at Messrs. W. Pope & Co.'s Barley Field Iron Works, in Bristol, a machine of English invention lately brought over from the United States, where, in the Californian, Colorado, Mexican, and Vera Cruz mining districts, some 300 or 400 are in use.

Finding on inquiry that this machine, known by the name of "Thompson's Patent Centrifugal Pulverizer," had overcome many of the objections made to the ordinary machinery used for crushing purposes, the writer thought a short descriptive account of the same, and its comparative advantages, might be of some interest to the members of this Institute, and therefore has great pleasure in giving them the following account of its application and use.

It seems that in Thompson's machine the old illustration of Newton as to the enormous power of a weight attached to a string and whirled round the head, has been applied with success in the effective and economical crushing and pulverizing of soft and hard substances.

The writer finds that attempts have been made, as far back as 1853, to apply the force resulting from the centrifugal motion imparted to a ball moving in a circular direction, for the pulverizing of animal and mineral substances, but hitherto little or no success has been met with owing to the intense friction involved in these applications, compared with the easy movement obtained by the simple flexible driving action for rolling the ball in Thompson's machine; for whereas in Thompson's machine the ball has a free motion, the other machines, while utilizing centrifugal force to some extent, waste considerable power in friction caused by the skidding action applied for imparting motion to the ball.

Plate IV., Figs. 1 and 2, will convey an accurate idea of the general character of this pulverizer.

The ore fed in at *t* is crushed between the hammered steel ball *b*, and the steel shoe ring *c* of equal hardness, the ball *b* being grasped between the flexible discs *d d*.

The discs *d d*, kept the proper distance apart by the springs *q q* grasping the ball *b*, are caused to revolve rapidly, and the centrifugal motion thus given the ball causes it to press against the steel shoe ring, while it is being carried around by the discs, crushing any ore that may be between the ball and the shoe ring. At the same time that the ball is being carried around the inner circumference of the machine, it is free to revolve on an axis which is continually changing.

As it is loosely grasped at two opposite points only, there is little or no scraping motion against the ring *c*, and the ball always presents new surfaces against the ore, preserving its spherical form until worn down too small for further use.

The ore, broken to a suitable size, mixed with water, is fed into the hopper *l*, and the pulverized ore passes out through screens at the side of the machine, or through a series of blades *k k* so arranged as to prevent the substance getting away from the ball until it is sufficiently reduced. Any ore which is not crushed sufficiently fine at the first revolution of the ball is brought back under the ball and crushed sufficiently fine by succeeding revolutions.

The following advantages of this pulverizer are especially worthy of note:—

1.—The large area of crushing surface presented by a plain steel ball, which exerts enormous crushing power and presents the whole of its surface for useful work.

2.—The friction, wear, and driving power are reduced to a minimum.

3.—Excessive speed and its attendant evils are dispensed with.

4.—Its suitability for crushing ores and other minerals, either coarsely or to an impalpable powder.

5.—Small quantity of water required in wet crushing.

6.—The inexpensiveness of the foundations, combined with the compactness and portability of the mill (an essential feature in unproven mines).

7.—Small first cost of the machinery and erections and reduced cost in the maintenance of the mill.

8.—Proper feeding and sifting, combined with a rapid and uniform output.

9.—The suitability of the mill as an amalgamator, thus saving the cost of regrinding the concentrates and pyrites, a process necessarily adopted in ordinary quartz crushing, owing to the coarseness of the ore after leaving the stamps.

10.—Keeping back rust gold when present, it being brightened owing to the peculiar action of the ball, and thus prevented from escaping.

11.—Its simplicity and few working parts; the only wearing parts consist of the ball, shoe ring, and the discs, which when worn unfit for further use can be speedily replaced.

12.—The adaptability of the mill for either wet or dry, hard or soft crushing, including such rocks as flints, coprolites, slags, cement, coal, iron ores, pottery, glass, etc.

It was explained to the writer, while seeing a machine at work that was manufactured in America, that the American machines were liable to have some of the pulverized mineral find its way into the bearings, but that this had been effectually overcome, in the English-made machines.

This machine had an internal diameter of only 30 inches, and carried a ball 8¼ inches in diameter, weighing 75 lbs., and during the time it was in operation it crushed with wonderful ease a quantity of rock known as Jasper.*

The action of the ball is concussive and rolling, and this action is such that the ball always retains the form of a sphere, and, presenting an always changing position, keeps the outline or contact face of the discs perfectly regular and defined.

The ball was perfectly round, and the path of the ball in the ring appeared to be exceedingly regular and uniform.

It is interesting to note that the area of crushing surface presented by a ball 8¼ inches in diameter is 213 square inches, and that in this small 30-inch machine, revolving at 300 revolutions per minute (this being about the speed required for the mill), the centrifugal force is equal to 2,079 lbs.

In a large mill, say 6 feet in diameter, with an 18-inch ball, weighing 780 lbs., the revolutions being 200 per minute, the force of the ball, obtained by its centrifugal motion, would be equal to 23,868 lbs., or nearly 11 tons, and the area of crushing surface would be 1,018 square inches.

These figures are worthy of note, inasmuch as in this later machine it will be observed that the area of crushing surface presented by the rolling ball is equal to over 7 square feet, and the original weight of the ball, although only 780 lbs., when travelling at a velocity of 200 revolutions

* Samples in both a crushed and uncrushed state were exhibited and inspected by the members.

a minute, attains the enormous crushing power of over 10 tons; this stupendous force so rapidly excited will explain why a machine on this principle and of the same size, viz., 6 feet, will pulverize the same quantity of rock as can be turned out by a 40-stamp battery.

The weight of the 30-inch mill is only 3 tons, and of the 6-foot machine 10 tons; stamping machinery of the same capacity as this latter mill would weigh between 100 and 120 tons.

In comparing the crushing power of this latter sized mill with the results obtained by edge runners, it should be remembered that this force of 10 tons is exerted around the periphery of the machine 200 times in each minute, while edge runners of weight sufficient to equal this force, could only travel twelve times per minute, and as this crushing force is acquired from the dead weight moved, it requires heavy and ponderous machinery of a power-absorbing nature; these remarks apply in a greater or less degree to rolls and burr stones.

The following extract, taken from the "Scientific American," in speaking of "Thompson's Pulverizer," will explain more clearly than the writer can, the great advantages of this mill, especially in places where scarcity of water exists :—

The fineness of the ore depends on the number of meshes of the screen and the quantity of water used; the more water used, up to a certain quantity, the more pulp will be washed out.

With very little water a less quantity will be done, but it will be very much finer. To give the mill all the water that can be used requires but 400 gallons per ton of pulverized ore. This compares very favourably with the amount of water used by the stamp mills. In the Black Hills, where they must economize water, they use 2,500 gallons per ton of ore; at the Rara Avis mine just enough water to carry the pulp over the plates was found to be all sufficient. This mill, which has used the machine (Thompson's) longest, is doing satisfactorily from 3 to 4 tons per hour with but little wear.

There is no wear of note on any part of the mill except on the ball and shoe ring. The latter is made of rolled steel; the ball is made of the very best coal blast charcoal iron, deeply chilled, which gives it a degree of hardness not exceeded by the best tool steel.

The amount of slime made is but a small percentage of that made by a stamp mill, and from the peculiar form of the pulp, it is more readily concentrated, as shown by actual workings on a very large scale.

The mill in its construction is very simple and easily set up, and any wearing parts can be replaced in an hour.

The lower half of each screen frame is supplied with a door which is hung on hinges, so that it can be raised and the mill cleared out while it is in operation if necessary.

It is not possible for rust gold to escape, as it is brightened by the rubbing it receives while in the mill.

A great point in the mill is its very low speed and small power required.

In a paper read before the Franklin Institute on January 18th, 1882, by C. Henry Roney, M.E., the following remarks, in reference to this pulverizer, and the following Table of Comparative Results will be found :—

Disregarding minor details, such as the driving pulleys, screens, bolts, and bearings, the entire pulverizer is composed of six pieces—the bottom, top, discs, ring, and ball.

The machine is divided directly through the middle, and requires no expensive foundation upon which to place it, three ordinary timbers answering all purposes, and but four bolts being required to hold it together, These removed in a few moments, the machine can be taken away bodily.

The wearing parts of the machine, such as the ring, in which the ball revolves, the rolls, the discs, and the ball itself, are made of the best chilled charcoal iron, much harder than the best tool steel, such tools as cold chisels having been ground in this pulverizer to demonstrate the hardness of the metal and effectiveness of the motion .

The hardest rock may be ground with very little motive power, the largest machine —they are made of three sizes—requiring but ten horse-power to pulverize 60 to 75 tons of ore per day, a quantity equal to the work of a 35-ton stamp mill; the next smaller size will pulverize about two-thirds, and the other about one-half of the amount done by the larger machine, with a proportionately small amount of power. The screen used is No. 60 mesh, and on testing the pulverized ore which passes through, it was found that 75 per cent. of it would pass through a 100 mesh screen, which is much finer than gold or silver ore crushed by ordinary stamp mills.

In order to compare the results obtained by this pulverizer with those given for stamp mills in California, Colorado, Lake Superior copper mines, etc., by Rossiter W. Raymond, U.S. Commission of Mining Statistics, Prof. T. H. Eggleston, C. M. Rolkes, M.E., A. J. Bowie, jun., Prof. H. S. Monroe (Trans. Am. Inst. Mining Engineers), and E. F. Althaws, U.S. Centennial Report, I have prepared a Table giving the maximum results obtained with stamps in different localities, together with those obtained with this machine.

In the large machine, the ball, originally measuring about 11 inches in diameter, weighing 180 lbs., is used until reduced to about 9 inches in diameter, weighing 100 lbs., losing 80 lbs. of metal, during which time it crushes about 320 tons of a hard Laurentian rock, giving a loss of about $\frac{1}{4}$ lb. of iron to each ton of ore crushed, while with ordinary stamps, one shoe, weighing from 300 to 320 lbs., is estimated to crush 40 tons of quartz rock before it is discarded, and loses from one to several pounds of metal to each ton of ore crushed.

The amount of water required per ton of ore for the pulverizer is also claimed to be less than one half of that required for a Californian stamp mill, a very important consideration when we understand the great difficulty in obtaining water which frequently exists in mining regions.

The ore receiver and elevator are not necessary where the rock breaker is placed on the floor above and the broken ore fed directly into the hopper, which is the most economical mode of feeding, and the plan recommended by the manufacturer.

TABLE OF COMPARATIVE RESULTS, FRANKLIN INSTITUTE TRANSACTIONS, BY C. H. RONEY, M.E.

Location of Mill.	Character.	Stamps.			Size of Screen.	H.p. per Stamp.	Tons crushed per H.p. in 24 hours.	Tons crushed per Stamp in 24 hours.	Shoes worn per ton crushed.	Water required per ton crushed.	Coarseness of Sands.					Space Occupied.	Character of Ore.
		Weight.	Fall.	No. of Drops per Minute.							1·25 to 3·16 in. per cent.	1·64 to 1·25 in. per cent.	Finer than 1·64 in. per cent.	Percentage passing a 60 mesh sieve.	Percentage passing a 100 mesh sieve.		
		Lbs.	Ins.						Lbs.	Gals.						Feet.	
California—Eldorado County ...	Californian pattern	665	10	80	No. 6	...	3·93	...	...	5·282	...	...	...	...	...	...	Quartz.
Do. Nevada County ...	Do.	1,000	11	60	...	...	2·00	...	...	5·282	...	...	...	...	...	...	Do.
Colorado—Gilpin County ...	Do.	900	15	50	...	...	3·30	...	...	...	...	...	...	...	...	...	Do.
Nevada—Virginia City	Do.	...	8	100	...	...	...	4½	...	...	...	...	...	...	...	...	Do.
Dakota—Deadwood	Do.	758	9	85	No. 6	...	...	3 1/10	...	...	...	...	...	...	...	...	Do.
Utah—Ontario District	Do.	800	8	92	„ 30	...	...	2¼	...	Dry	...	...	...	...	...	...	Very hard.
Michigan—Lakes Superior, Calamnt, and Hecla	Ball steam hammer stamp	4,500	20	90	3/16	60	2·00	120	1	7·925	28	20	52	...	...	15½ × 12½	Conglomerate.
Michigan—Lakes Superior and Phœnix	Atmospheric stamp	270	16	120	...	...	...	6¾	...	...	...	...	...	...	...	...	Do.
Brazil—Mono Velho, St. John del Rey	Cornish pattern	640	12	73	...	...	1·41	...	...	...	...	...	...	...	...	...	.....
Australia (Clunes)—Port Philip Company	Do.	800	8	75	...	...	3·30	...	...	...	...	...	...	...	...	...	.....
Australia (Clunes)—Port Philip Company	Do.	800	8	75	...	...	2·42	...	..	...	...	...	...	...	...	...	.....
		Ball.															
Thompson's Pulverizer, size B ...	Centrifugal ball	180	...	230	No. 60	10	6 to 7½	60	¼	625	...	...	...	25	75	7 × 4	Very hard & tough Laurentian rock.
Do. „ C ...	Do.	120	...	300	„ 60	6	6	30	¼	625	...	...	...	25	75	5 × 4	Do.
Do. „ D ...	Do.	70	...	400	„ 60	4	6	15	¼	625	...	...	...	25	75	4 × 3	Do.

In order to make the Table of Comparative Results, given by Mr. Roney, as clear as may be, the writer has taken the following "Table of Dimensions and Duty" from the recent and comprehensive book on "Gold: its Occurrence and Extraction," by Alfred G. Lock, F.R.G.S.

Mr. Lock says:—"The annexed Table reveals at a glance the dimensions and working results of a number of mills in various parts of the world, including some that may be considered representative."

TABLE OF DIMENSIONS AND DUTY.

See "GOLD: ITS OCCURRENCE AND EXTRACTION," BY A. G. LOCK, F.R.G.S.

MILL OR DISTRICT.	Weight of Stamp.	Drops per Minute.	Depth of Drop.	Crushed per 24 hours.	No. of Stamps.	Duty per Stamp.	H.p. per Stamp.	Holes per Sq. In. of Grating.	Water per Stamp per 24 hours.
	Lbs.		Ins.	Tons.		Tons.			Gallons.
Grass Valley ...	850	61	10	40	20	2	...	...	...
Do. ...	700	68	10	32	20	1·12	...	...	...
Eureka ...	950	80	9	...	60	2½–3	...	...	...
Brunswick ...	...	...	...	160	56	3	...	...	...
Regstone ...	750	75–80	...	75–80	24	2	...	...	...
Idaho	950	80	9	...	...	...	...	...	...
Metaloni ...	900	90	10	...	...	...	...	...	...
Port Philip ...	672	75	...	...	...	2·2	1	...	...
Do. ...	896	75	...	...	...	3	1¼	...	...
Nova Scotia ...	650	55	6–9	...	...	1 –1½	...	...	...
	Cwt.								
Ballarat ...	4 –8½	50–85	7 –10	...	...	1 –4	1 –2	40–200	950– 8,640
Buckworth ...	4¼–7¾	40–90	5 –14	...	...	¾–4	¾–1½	60–140	720–11,520
Sandhurst ...	5 –8	25–75	6 –18	...	...	1 –3¾	½–2	64–140	4,000– 8,640
Maryborough ...	4½–8	50–75	6 –22	...	...	1 –3	½–2½	70–144	900– 8,640
Castlemain ...	4½–8	35–75	6 –15	...	...	1 –3¼	½–2	40–144	4,800–12,960
Ararat ...	5 –6¾	60–72	7½–10	...	...	1¼–1½	¾	90–120	4,320–12,960
Gippsland ...	6 –7½	60–80	7 –10	...	...	1½–2	¾–1½	70–250	1,600–25,000

In the same work the following appears, in reference to Thompson's pulverizer:—

The action of Thompson's pulverizer consists in the use of a heavy ball within a revolving drum, the ball being thrown by centrifugal force against the material to be crushed.

The size weighing 5 tons, and running with a 190-lb. ball, requires 10 horse-power, and pulverizes 60 tons per twenty-four hours to a degree that allows it to pass through a 60 mesh sieve.

Allowing the latter part of the paragraph to be correct, the explanation of the principle of the machine is here not very clear. The ball and discs while revolving on different axes necessarily take the same direction, but the shoe ring around which the ball travels is stationary.

By referring to Mr. Roney's "Table of Comparative Results," and to Mr. Lock's "Table and Dimensions of Duty," it will be observed that

whereas the mineral pulverized is made to pass through screens with 3,600 holes to the square inch in "Thompson's Pulverizer," the size of the screens in the others in no case exceeds 900 holes to the square inch.

It should also be noted that Mr. Roney states that on testing the pulverized ore 75 per cent. was found to pass through a mesh containing 10,000 holes to the square inch.

Many mining engineers have frequently pointed out that the evil of the present system of treating gold quartz consists in the fact that the meshes used on the boxes of the stamps have too few holes to the square inch, and consequently allow the crushed material to pass over the mercury tables without being of sufficient fineness to liberate all the free gold; this was found to be so in the case of the Indian gold mines, and screens with meshes of from 2,000 to 3,500 holes per square inch were sent out to be introduced on to the boxes of the stamps, but they would not answer, as the boxes immediately filled with the crushed mineral, the stamps not being able to pulverize the ore to a sufficient fineness.

With stamps weighing 900 lbs. each, and screens fixed at both the front and back of the boxes, it was found that not 10 per cent. of the original output could be maintained with these screens.

It is well known that in ordinary stamping, duplicate stamps and shoes are required to replace those discarded or thrown out, and the writer can corroborate the figures given by Mr. Roney as to the loss of metal in stamps, and the waste occasioned by the wear of the stamp heads and shoes, which after a short use are of no further commercial value; it is, therefore, important to mark the figures given of the wear of Thompson's machine, which shows in exceptionally hard rock a wear of only $\frac{1}{4}$ lb. of metal for each ton of ore crushed.

It is also stated that as the ball always retains its spherical form there is practically no waste, as the ball, although rendered useless for the original machine by its wear, can be further used for smaller machines, which, in many cases, may be on the premises.

Reference has been made at the commencement of this paper to the bulky nature of the machinery used for ordinary crushing purposes, and also to the expensiveness of the foundations required. It is no uncommon occurrence in foreign mining enterprises to find that two or three years are spent in getting the mill to the mine and having it fitted up for work, where not unfrequently it remains without doing any work whatever, the property having been proven in the meantime to be quite valueless.

It occurs to the writer that it would be much better, in all cases where the mine is not thoroughly proven, that some suitable but inexpensive and portable machinery should in the first instance be erected, which would be able without any appreciable delay to prove the value of the property.

That this is what is wanted everyone has admitted, but it has always been contended that there was no suitable machinery for this purpose; as, however, a small mill like the one described can crush the hardest rocks, the writer considers this difficulty has been overcome.

It may be contended that it would be unwise to erect a mill which would be unequal to the output of a successful mine, but it must be noted that a small sized 30-inch machine is capable of turning out as much crushed ore (the meshes containing 3,600 holes to the square inch) as a mill of fifteen head of stamps weighing 900 lbs. each with meshes containing only 900 holes to the square inch; it is also natural to suppose that the former of these mills would, by crushing the ore finer, give a truer insight into the value of the property.

Unless a mine is thoroughly proven it is always unwise to erect a permanent mill in any particular position, because it is impossible to say where the majority of the ore may possibly come from, and it has already been pointed out that the cost of transit of the material should be kept as low as possible. In ordinary stamping machinery, when once the mill is erected, the transit of the ore must be made subservient to the position of the mill, while in using "Thompson's Pulverizer," the machine could be moved from place to place with comparatively small cost.

In the silver mines of Mexico it is found that the finer the ore is crushed the more perfect is its transformation into chloride by roasting, and, doubtless, in the treatment of most minerals which occur either in chemical or mechanical combination with other substances, the finer they are pulverized the cheaper and more effective will be their subsequent treatment.

The tin ore of Cornwall in many cases has to be finely ground, and by the application of pneumatic stamps the pulverized material is able to pass through meshes with 1,296 holes to the square inch, and it would be interesting to learn whether the treatment might not be still further improved if the ore were pulverized finer.

With respect to the suitability of this machine as an amalgamator, it may be remarked that in many mines where the concentrates and pyrites are rich they undergo a further re-grinding process in wheelers, pans, or

other appliances, in order that they may be reduced to as fine a pulp as is possible before amalgamation; this requires considerable additional motive power, which is saved in Thompson's machine, owing to the fineness of the ore already crushed, so that instead of having to operate still further on the concentrates and pyrites, the mercury can be either placed in the mill itself, or the concentrates can be treated in a similar machine specially designed for that purpose.

Another important consideration in treating minerals is the cost of the machinery and its maintenance, and here again this pulverizer shows a considerable advantage over other mills.

Mr. Lock, in his book, gives the total cost of an eighty head gravitation stamp mill, capable of crushing 120 tons in twenty-four hours, including freight, foundations, buildings, etc., delivered in India, as £7,190, and of twenty head of Elephant stamps, crushing the same quantity of rock, £3,455.*

These figures appear if anything to be within the mark, as the writer knows of instances where forty stamp batteries, capable of crushing only 80 tons in twenty-four hours, have cost between £9,000 and £10,000 inclusive of freight, buildings, etc.

It is estimated that "Thompson's Pulverizer" would, with a guaranteed capacity of 60 tons in twenty-four hours, doing up to 75 tons, cost £1,800 including freight, erections, and buildings.†

It will be observed on reference to the aforesaid tables that the motive power required for the various mills ranges from one to two horse-power per ton of ore crushed, while this pulverizer gives from 6 to 7½ tons‡ per horse-power, with the ore passing through meshes of a degree of fineness impracticable in ordinary stamping machinery.

In one of these 30-inch dry mills erected in America for grinding hard phosphate rocks, twelve horse-power crushed 2,900 lbs. per hour, much finer than formerly twenty-five horse-power crushed 1,000 lbs. per hour with burr stones.

Having somewhat fully discussed the suitability of this pulverizer for the crushing of mineral ores, the writer would now wish to shortly point out the merits of the machine for the grinding of coal.

Fig. 2 is a section through A A Fig. 1 of the same machine, and shows the active principle of the machine without any of its exterior fittings. Fig. 1 represents the transverse section of a complete mill fitted up in

* These figures are given by the maker of the Elephant stamps.

† Estimate made to the Indian gold fields.

‡ See Mr. Roney's Table of Comparative Results.

its entirety, which, with certain modifications that might be necessary under varying conditions, seems admirably suited for the grinding of coal with very small motive power.

The ordinary coal disintegrators are acknowledged to be very great consumers of power, owing to the excessively high velocity at which they have to run; a velocity necessary not because of the force required to break or disintegrate large masses of coal, but because the smaller the particles are broken, the greater is the velocity or force that must be imparted to reduce them still finer.

In other words the action on the coal is irregular, too much power being applied to the coal as it is fed into the mill, in order that there may be power sufficient to reduce the coal to a uniformly fine dust; for the present class of disintegrators, if running at low velocities, does not sufficiently reduce the coal to the size required for coking purposes, but by the adoption of a machine such as that illustrated, modified according to the conditions of the mine, the coal would be ground to any desired fineness with small motive power.

The action of this machine is entirely different to other disintegrators, for the crushing and grinding force is perfectly equal and regular, and is maintained at a low velocity.

The substance to be acted on falls from the hopper *t* into the feed wheel *y*, forming one end of the rotatory sieve *x*, and taking its bearing on the neck of the standard *e*. This wheel is constructed with an incline trough-like rim fitted with feeding buckets, so that the substance falling into the rim passes through the open spaces between the arms *f* into the buckets, which, in course of their rotation with the wheel, elevate and feed it into the mill hopper *g*, from which it passes through the channels *h h* into the circular mill ring *c*, where it is operated upon by the centrifugal force of the ball *b*.

For coal grinding, instead of using the screens, a series of blades *k k*, are so arranged as to prevent the substance from getting away from the ball until it is sufficiently reduced.

The mill is so encased that the substance, after passing through the spaces between the blades, falls into the receptacle *m*, which is constructed with a door *n*, so arranged as to accumulate and retain a quantity of the substance passing from the mill, while a given quantity is under the process of sifting by the rotating sieve which is fitted with a collector *o*, at every revolution, the sieve gathers and returns to the mill hopper for re-grinding such quantity of the substance as may be too coarse to pass the meshes.

To illustrate Mr. T. E. Candler's paper on "Thompson's Patent Centrifugal Pulverizer."

FIG. 1.

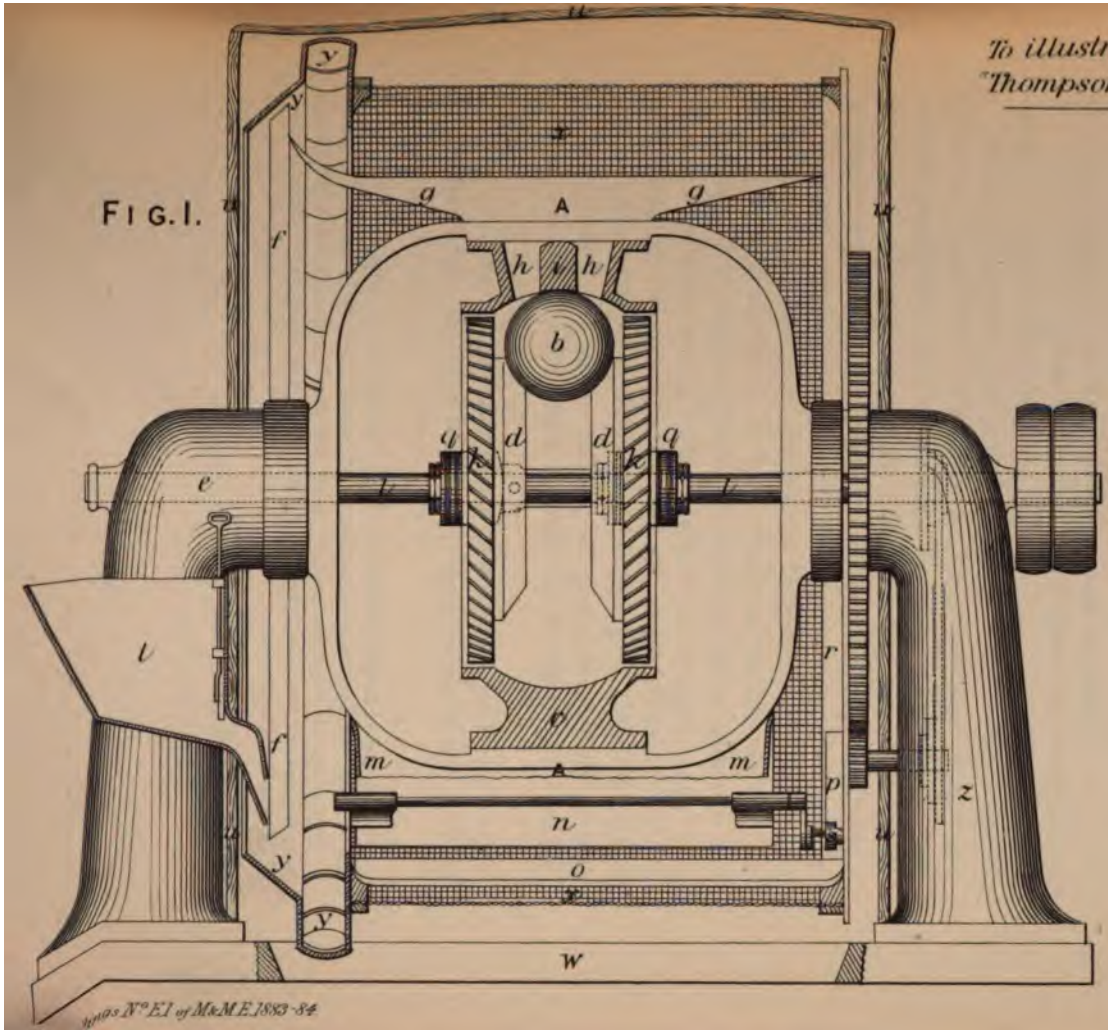
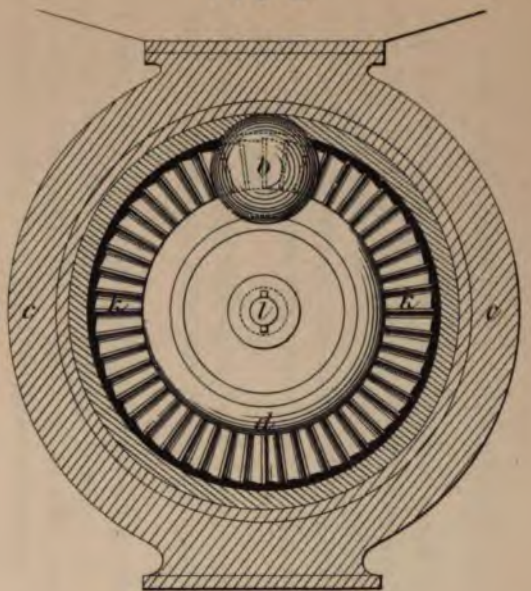


FIG. 2.



SECTION THRO. A.A. FIG. 1.

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The collector having passed the outlet of the receptacle in course of its revolution, a projection *p* in the wheel *r*, forming the sieve end, comes in contact with the roller *s*, lifting it up in such a manner as to open the door of the receptacle and retain it open sufficiently long to admit of the ground or pulverized substance accumulated therein being deposited on to the meshes of the sieve.

The projection passed, the door again closes to retain or accumulate another quantity of substance while that it has just deposited is being sifted.

The rotary motion is imparted to the feed wheel and sieve by their connection with the wheel *r*, which receives a slow motion from the shaft *l*, by means of gear *z* as shown. The casing *u* prevents the escape of dust, and the substance falling from the sieve passes through the open space *w*, to which any suitable shoot or receptacle may be attached.

The degree of fineness required can be regulated by the pitch and distance apart of the propellers *k k*.

The use of this pulverizer is not confined to mining, it can be applied under very favourable circumstances for the pulverizing of fireclay and other substances used for brick-making; the fineness of the fireclay after treatment would probably render the bricks of greater value than they are at present, and the cost of production would be considerably cheapened.

In many manufactures, ganister, spiegeleisen, slag, glass, pottery, and various chemicals, are required to be ground, and as the cost of this is considerable, it is worth while to inquire whether the application of Thompson's Pulverizer would not be an advantage and effect a considerable saving; this remark would doubtless apply with even greater force to the important industry of cement manufacture, to the crushing of many of the hard rocks used for making the various kinds of paints, and to the crushing of phosphate rock for farming purposes; in all of which cases the finer the substance is ground the better.

The following extract taken from "Chemistry of the Farm," by Mr. James Macfarlane, analytical chemist, will show the use of this machine for treating coprolites:—

Coprolites; owing to their animal origin we reasonably expect to find the exterior crusted or indurated, through having been acted upon by atmospheric agencies, and necessarily poorer than the interior and softer portion, and hence the advisability of using a machine for grinding them which will effectually separate the two qualities, the outer or poorer portion and the inner or richer, such a machine for instance as Thompson's pulverizer.

In concluding this paper the writer would remark that after seeing this pulverizer at work, his wish has been to bring before the members of this Institute a description of a machine which appeared to him to have merits worthy to be placed on record.

The PRESIDENT said, the machine seemed to be a very beautifully designed one, and no doubt was very efficient in its working; but it would be required to be studied before the subject could be discussed. He proposed a vote of thanks to Mr. Candler.

The motion was agreed to, and the meeting concluded.

PROCEEDINGS.

MEETING, TUESDAY, MARCH 18TH, 1884, AT THE GREEN DRAGON INN, WORKINGTON.

GEORGE BAKER FORSTER, ESQ., PRESIDENT, IN THE CHAIR.

A meeting of members of the Institute interested in the geology of the Cumberland Coal-field was held at the Green Dragon Inn, Workington, for the purpose of discussing Mr. J. D. Kendall's papers "On the Structure of the Cumberland Coal-field" and "On the Hæmatite Deposits of Furness." Between forty and fifty members were present.

The PRESIDENT said, that at the meeting held at Barrow it was suggested that, as the time then at the disposal of members was far too short to exhaustively discuss the subjects of Mr. Kendall's papers, a supplementary meeting should be held at which members living in the neighbourhood of the district described could fully and fairly discuss the points raised respecting the local geology. They had now assembled to hear what was to be said.

Mr. KENDALL said, he did not think that he had anything further at present to add to his papers, but he would call attention to a few corrections he wished to make in the paper "On the Cumberland Coal-field." At page 340, Vol. XXXII., in the tenth line from the bottom, it should read "Ten-quarter Band of Ellenborough," instead of "White Metal Band of Ellenborough." On Plate XXXII. the outcrop of the Yard Band at Aspatria, and Old Brayton Domain, was marked Main Band. Although, according to his correlation, it was equivalent to the Main Band at Bolton and Mealsgate, it should not be marked Main Band at those collieries, because it was there called the Yard Band, that is, at Aspatria and Old Brayton Domain. On Plate XXXVI., in Section No. 7, at the Harrington Colliery, "Three-feet Seam" was written twice over, but the top one should read "Two-feet Seam." On page 356, in the seventh line from the bottom, for "towards the east" read "towards the west." He might mention there was a seam which he had

not taken any notice of in the paper, which was known in one part of the district—Studfold Colliery, near Gilgarran—as the China Band. He correlated this band with the Yard Seam of Gilgarran and the Six-quarter of Whitehaven, which, he believed, would be considered a piece of heresy; but probably some of the members present would show where he was wrong.

Mr. FLETCHER said, it was only due to Mr. Kendall that some one who had had a long practical experience like himself (Mr. Fletcher) of the coal-field of West Cumberland should make some observations upon this very excellent paper. They would all agree with him in complimenting Mr. Kendall on the great pains and research he had taken to put the matter clearly before them. The paper showed that the writer had a scientifically constituted mind and a great amount of scientific training. There were, however, some errors to which he would draw attention. In the section given by Mr. Kendall of the Aspatria No. 1 Pit, at page 337, he gave the thickness of the Little Main Coal at 2 feet 2 inches. On reference to the actual boring journal he (Mr. Fletcher) found that this thickness of the seam included impurities, the greatest part being what was called "Rattler" in this district—that was bituminous shale. Therefore, the seam, which might appear to be workable according to the paper, was in reality unworkable. On page 350, Mr. Kendall gave the thickness of the Six-quarter Band at Melgramfitz Colliery at 2 feet 11 inches; this was only part of the seam. The upper coal was 1 foot 10 inches, shale or thill 10 inches, lower coal 2 feet 11 inches, making altogether 5 feet 7 inches of coal, instead of 2 feet 11 inches. On page 344, Mr. Kendall stated that he considered the Crow Band and the Ten-quarter or Master Band of the Mealsgate district both lie in the Whitehaven sandstone. In this he was quite sure, from his experience, that Mr. Kendall was mistaken. He (Mr. Fletcher) had a pit which went right through these bands or seams near to Mealsgate, and they were found in the ordinary coal measures and some fathoms below the base of the Whitehaven sandstone, they were conformable with other seams of coal of the Carboniferous series, and were not conformable with the Whitehaven sandstone. On page 349, Mr. Kendall correlated the Thirty-inch Seam in the Aspatria and Mealsgate districts with the Crow Coal of the Workington and Whitehaven districts. In this, he believed, Mr. Kendall was mistaken also. From the experience he had had of these seams both at Mealsgate and near to Workington, he thought there was little doubt that this was a seam which, at Clifton and Greysouthen, was called the Black Metal Band, and lies nine or ten

fathoms above the Main. At Aspatria and Mealsgate it thickened to about three feet, and went by the name of the Thirty-inch Seam. On page 340, Mr. Kendall pointed out that in his opinion the Lickbank or Six-quarter Seam that was worked at Broughton Moor and Dearham did not correspond with the same seam in other parts of the district. That he (Mr. Fletcher) thought was an error. According to the borings, and according to the actual working of this seam at Dearham, it no doubt represented the Lickbank Seam throughout the Workington part of the district. Mr. Kendall had omitted in his paper to refer to the coal in the east part of Cumberland; but he had, no doubt, intentionally confined himself to the west part of Cumberland. It was worth while mentioning that at Naworth Colliery, in the neighbourhood of Midgeholme and Tindal Fell, there was a seam three feet thick, which lies within the Carboniferous limestone. So far as he knew there was no other instance of coal being worked in the Carboniferous limestone.

The PRESIDENT—In Northumberland there is.

Mr. FLETCHER—It is probably a continuation of this limestone.

The PRESIDENT—Yes, it is.

Mr. PEILE—Coal is also worked in the Burgh district, at Towcet, not far from Lowther, near Penrith.

Mr. FLETCHER—In Scotland there is some worked. In regard to the correlation which Mr. Kendall argued existed between the Rattler Band, worked at Maryport and Workington, with the Bannock Band at Cleator Moor, he (Mr. Fletcher) entirely agreed with the theory he had propounded. Without wishing at all to detract from the merits of Mr. Kendall's remarks on the subject, it was only right to mention that the late Mr. Isaac Fletcher, almost thirty years ago, when he was consulting viewer for some collieries at Cleator Moor, found, to his own satisfaction, that the Bannock Band there worked correlated with the Rattler Band in the Workington and Maryport districts. Mr. Isaac Fletcher communicated his view on the subject to the late Mr. Thomas Emerson Forster—the worthy sire of a worthy son—and also to Mr. Peter Bourne, who at that time was Lord Lonsdale's viewer, and at first they were doubtful, but they came round to Mr. Fletcher's view; and it was established, as shewn in this paper, that the seams were identical. Mr. Kendall pointed out the correlation of the Cleator Moor Five-feet Seam with the Ten-quarter Seams in other parts of the district, and in this he thought he was perfectly right; but he thought Mr. Kendall was entirely in the wrong in attempting to correlate the Six-quarter Seam with what he called the China Band at Oatlands. He (Mr. Fletcher) thought it was beyond

question that this China Band was the same as the Five-feet or Ten-quarter Seam at Cleator Moor and other parts of the district, as it there lies above the Bannock and Main Band as well as the Lower Seam that has been spoken of. In fact, at Oatlands Pit they had actually proved the existence of the Bannock Band 12 fathoms under this China Band. Lower down they ought to have found the Main Coal. The roof was there, and the sill was there; but the coal itself was wanting, they had reason to believe, in consequence of the extension in that direction of a nip found in another colliery a little to the rise. He pointed this out with great respect for Mr. Kendall's superior knowledge, but at the same time with great certainty that, upon practical grounds, he (Mr. Fletcher) was right. As to the Bannock Band, there was, he believed, little doubt that the Upper Seam that had been worked at the new colliery near to Siddick was the Bannock, or what, in the more eastern part of the district, was called the Rattler Band. At that point, he believed, the Ten-quarter Seam, which usually lies above the Bannock or Rattler was wanting. There was one part of the district where the two seams were found in an unusual state of perfection, and that was at the William Pit at Clifton Colliery, now belonging to the West Cumberland Iron Company, and sunk under his direction about twenty years ago. There was the Upper Seam, the Ten-quarter, about 5 feet 10 inches of almost clean coal, and 7 fathoms below that there was this Bannock or Rattler Seam, as follows:—Rattler, on the top, 8 inches; pure coal, an extraordinary fine quality, 3 feet 2 inches, and cannel below 5 inches, making a total thickness of 4 feet 3 inches. He regretted to say, however, that the Bannock or Rattler Seam in this state of unusual perfection extended only a small distance from the pit; perhaps it did not cover more than 8 or 10 acres; and in the rest of the Clifton-Greysouthen district it was not more than 18 inches thick on the average. Mr. Kendall alluded to some great nips found in the coal-field, especially to one at Workington, and to another in the neighbourhood of Camerton. Mr. Kendall seemed to be of the opinion that the one nip was a continuation of the other coming down the valley of the Derwent. In this view he thought Mr. Kendall was mistaken; because the Main Band Seam, in an unusual state of perfection, 9 or 10 feet in thickness, had actually been worked between the two points mentioned by Mr. Kendall—between Camerton and Workington—showing that the two nips must be entirely distinct. Unfortunately, there was a nip of great magnitude in the Camerton district, and it had played great havoc with the coal-field, as he knew to his cost; because where he expected to have nearly 1,000 acres of Main Band Coal there was actually nothing. The nip at Working-

ton was probably quite as extensive, and it had been a source of great loss and also of grief to the late Mr. John Christian Curwen, who sunk the deep Isabella Pit; and it was the disappointment caused by this and other nips that used to make Mr. Curwen say that "two hitches and a roll were better than one nip." After sinking the Isabella Pit at a cost of £80,000 down to the position of the Main Band, which in that district was 10 feet thick, Mr. Curwen found the coal absolutely denuded, and he drove a drift a good distance before he came to the coal. It would perhaps have been better if Mr. Curwen had closed the colliery when he came to the nip, because afterwards the sea got in and drowned a great part of the Workington Colliery. The nip, in the Camerton, Ribton, and Seaton districts altogether, probably covered an area of 1½ square miles. There were 1,000 or 1,200 acres there in which the Main Band was, as far as they knew yet, absolutely wanting; and many researches had been made at different times in these royalties. The deepest boring was put down by the West Cumberland Iron Company two or three years ago, and it went as far as 48 fathoms below the Ten-quarter Seam without finding anything, not even a trace of the Main Band, the place of it and of the shales which usually enclose the Main Band having been taken by freestone. Of course it was barely possible that the failure of the holes to find the Main Band might be due to the thickening of the cover. No doubt the cover did vary very much in different parts of the district. For instance, within a space of three-quarters of a mile at Clifton, the thickness increased from 16 or 17 fathoms at one point to 30 fathoms at the Lowther Pit. He believed twenty or thirty holes had been bored in the three manors in search of the Main Coal. He entirely agreed with Mr. Kendall's remarks respecting the unproved district, marked red in the plans, lying north of the Maryport and Carlisle Railway. The Mealsgate coal-field, and also the Aspatria district, was bounded by an enormous down-throw fault to the north, and over that fault only two attempts had been made to find the Main Coal, and he need not refer to them as both were explained by Mr. Kendall. Both attempts were unsuccessful. One went down 1,100 feet, and only got to the top of the Whitehaven sandstone. There was no doubt in his mind that most of the seams in this district did extend over the whole of that country, which goes much further than shown on the plan; it included some score of square miles. In his opinion—though it might be after all of them had passed away—the future prosperity of this district would be very much based upon the development of that coal-field. Mr. Kendall did not, he thought, say anything in his paper as to the quality of the coals in Cumberland, and therefore, for the benefit of their friends who had come from

a distance, he might briefly speak of one or two coals. The Main Band, as worked at Whitehaven, Workington, and other parts of the district, produced coal of excellent quality indeed, both for household and steam purposes. For 200 years at least the coal at Whitehaven had been the leading coal in the Dublin market, owing to its excellent burning property, its freedom from sulphur, and its ability to bear transit. Some of the coals were excellent for gas-making. His friend, Mr. J. S. Simpson, was now working some coal at Harrington—he thought the Six-quarter Seam, which was worked at the deep pit at Harrington—and the coal produced over 11,000 feet of gas, with illuminating power of 18 or 19 candles.

Mr. J. S. Simpson said Mr. Fletcher was right as to the quantity, but the illuminating power was 14 or 15 candles.

Mr. Fletcher said he did not think there was a coal in the Newcastle district which did more than that. Near Dearham, a superior kind of cannel had been found, which, for gas-making purposes, was equal, perhaps, to the Boghead cannel in Scotland. He did not know that the quantity of gas produced was more than Mr. J. S. Simpson's, but the illuminating power was between 30 and 40 candles, and the excellence of this cannel coal was shown by the fact, that it had a ready sale at 25s. per ton at the pit. For a long time the seams in this district were considered to be unsuitable for coke-making, in consequence of the high percentage of sulphur; but since the iron trade took root in West Cumberland and caused a good local demand for coke, it had been found that some of the thinner seams, not previously worked, were purer in quality that the others and quite suitable for coking. Mr. Snelus could tell them that the coke made from the Little Main Coal did not contain more than 1 per cent. of sulphur, and that local coke of this class was becoming more and more in request every year. When he was first connected with the iron trade, twenty years ago, he did not think there were more than twenty coke ovens in West Cumberland, and now there were built or building 700, and the probability was, that the number would be greatly increased. He mentioned this more as a matter of information than of gratification to their friends in the east, who, for a long time, had had undisputed command of the coke market at a high price.

Mr. John B. Simpson said, Mr. Kendall, in his paper, had raised some important questions. The first point he would like to draw attention to was, not with respect to the nature or identity of the seams, but to the similarity which existed between the Newcastle coal-field and the Cumberland coal-field, in what might be called its stratigraphical character. The thickness of the coal-measures in Cumberland was put down at 2,078

feet, those of Newcastle were generally estimated at about 2,200 feet. Mr. Kendall stated the thickness of the coal altogether was about 50 feet of workable coal, and that did not include the thin seams. In the Newcastle district there was about 75 feet of coal altogether, but this thickness included the thin seam coal; he supposed about 50 feet was the probable thickness of the workable coal. Another point of interest was that in the first part of the Newcastle coal-measures, viz., in the first 1,100 feet, there was a barren district similar to that of the Whitehaven sandstone, in which there are no seams of coal of workable thickness; the first they came to was the High Main, at about 1,100 feet, and below that for 700 feet, there were the workable seams of the Newcastle district, and in about the same zone occur the workable seams in Cumberland. Then below this was 400 feet, making 2,200 feet to the millstone grit, which was about 400 feet thick. The Newcastle millstone grit did not contain any workable seams of coal, nor did he think that any millstone grit in West Cumberland contained any workable seams. He asked Mr. Kendall whether he knew exactly the thickness of the millstone grit; as it was not stated in the paper. The other point to which he wished to draw attention, and which Mr. Kendall did not go into, was the duration of the coal-field. On referring to the Report of the Royal Commission in 1871, he found that the total quantity of coal in the Whitehaven coal-field, taking the seams above 30 inches in thickness, was 250,000,000 tons, and under the sea, taking 8 miles in length by 2 miles in breadth, gave another 100,000,000, making about 350,000,000 tons of coal altogether. If they assumed that the output of coal was, as Mr. Fletcher told them, 2,000,000 tons a year, that would give 170 years, and if they deducted the 13 years passed since the report was made, there was now only 157 years. This seemed to be a short period, but he was glad to hear from Mr. Fletcher and Mr. Kendall that there was every probability of seams being found under the Permian formation, which probability he hoped would be realized. As to the carboniferous limestone formation at Acomb, near Hexham, there was a 4 feet 4 inch seam in the upper part of it; at Plashetts, also, there was another seam 4 feet thick, which was still lower in the formation. In the north part of Northumberland there were many seams in the mountain limestone. The Blenkinsopp Seam was about 3 feet in thickness, and he had no doubt it was probably the same age as the Acomb Seam, or thereabouts. He thanked Mr. Kendall for the able paper which he had prepared.

Mr. Peile said, they were all much indebted to Mr. Kendall for his excellent paper. He had taken great pains in collecting

his information, and had prepared it in a manner useful to refer to. Mr. Kendall stated that the dip of the Workington coal was to the north; the dip was to the west. A series of upcast faults thinned off the coal-measures to the south. The dip was about 9 inches to the yard. Mr. Fletcher had spoken of the Isabella Pit being sunk and the drift having been driven about 600 yards. He (Mr. Peile) thought the Main Band Seam was found to be 4 inches at the nip in the pit, but after driving a drift about 100 yards, the Main Band Seam was then found in its usual thickness. Mr. Fletcher spoke of the Ten-quarter Seam being a good thickness at Clifton Colliery for a small area, and he (Mr. Peile) thought it was a well-developed seam of 6 feet in thickness at Crosby Colliery, extending over a large area and adjoining the fault referred to in that district. Looking at the unworked seams of coal before them, the seams below the cannel, and Metal Band or Main Band Seam, were what they had to look to in the future, and the most important one was the Six-quarter, which was known by different names, the Lickbank, Hamilton, and the Yard in some places. Where this seam was found to be thin, it was the upper part of the seam only, and it seemed to be general all throughout the district, and where it was thicker, it was a lower coal which was absent at other places. He endorsed what Mr. Fletcher had said as to the quality of this seam; it was the best in the district.

The PRESIDENT asked whether there was not a seam proved at Workington below the Hamilton Band?

Mr. PEILE—There is the seam known as the Virgin Seam which is the Four-feet Seam, and which corresponds with the coal found at the Countess Pit and elsewhere, and lower down there should be the Udale Seam.

The PRESIDENT—Is the Udale Band the lowest proved seam?

Mr. PEILE—Yes; so as far as Workington and Harrington Collieries were concerned.

Mr. FLETCHER said, Mr. Peile was correct as to the distance driven in the Isabella Pit. He thought Mr. Peile was wrong as to the dip and rise at the Isabella Pit; he (Mr. Fletcher) thought the rise was to the south-west.

The PRESIDENT said, he thought the dip was into the sea.

Mr. T. P. MARTIN said, he endorsed all that Mr. Fletcher had said respecting the value of Mr. Kendall's paper, and personally he felt very much indebted to Mr. Kendall for having gathered together so much useful information and having put it into such a clear and intelligible form. Taking the Permian strata as being the most recent formation connected with the

coal-field, and the existence of coal under which was a question likely to be of serious importance in the future, he would like to ask one or two questions respecting it. He wished to know whether any further particulars could be got respecting the borehole at St. Bees. As to the respective thicknesses of the St. Bees and the Whitehaven sandstones—the depth between the two sandstones—whether any gypseous shales had been found between them, and also the depth from the base of the Whitehaven sandstone to, say, the Main Band Coal? These particulars would give some idea of the amount of unconformity of the two sandstones to themselves, and also to the underlying coal-measures between the point where the latter disappear under the former, and where they have been proved by the borehole. Mr. Kendall said that the Allerby borehole proved 53 fathoms 1 foot 6 inches of Permian and Whitehaven sandstones. He would like to know how much of this was Permian and how much of Whitehaven sandstone. Did the borehole prove the full thickness of the Permian and Whitehaven sandstones, or did it pass into the upcast side of the fault before proving the full thickness? An attempt had been made in the Bullgill Pit to set through the fault and bore down, but, so far as he was aware, without success. Mr. Kendall mentions that at Ellenborough Colliery the fault was drifted into for 21 feet from the Ten-quarter Seam, at a depth of 120 fathoms, proving grey and brown sandstone, and which he thinks was probably Whitehaven sandstone; but which Mr. Steele—who was manager of the colliery at that time—informed him (Mr. Martin) was certainly St. Bees sandstone. At the Aspatria No. 3 Pit, an attempt had also been made to prove the throw of the fault from the Yard Band, but, he believed, without any satisfactory result. In his opinion the displacement of the strata did not exist as one large fault, but as a series of faults, and to prove the full "throw" by drifting from the up-cast side, it would be necessary to go a considerable distance beyond the line where the fault was first met. Particulars had come under his notice of a borehole which had been put down at Carlisle, proving the St. Bees sandstone at 45 feet from the surface, and afterwards passing 550 feet into the sandstone. The stone was said to be hard and close, with very little water. The Kelsick Moss borehole proved sand and gravel, 92 feet; clay, 106 feet; gypseous shales, 700 feet; and below this the St. Bees stone. At Bowness-on-Solway a borehole had also been put down, proving drift, 41 feet; gypseous shales, 367 feet; and below, the St. Bees sandstone. It would appear from these particulars that there was a thinning of the upper Permians in the direction of Carlisle, or that at any rate the enormous thickness of surface drift was reduced

and the gypseous shales wanting altogether. Of course, if, as it is supposed, the Kelsick Moss hole is upon the line of a fault, that may account for the abnormal thickness of drift and gypseous shales at that point. The relationships of the Canobie coal-field to this one was also an interesting question. Mr. Kendall mentioned it as being in the lower carboniferous rocks, and in this he appeared to be correct. From a quotation in Hull's "Coal-fields of Great Britain," Professor Geikie—he believed it was—in his report to the Coal Commission, supposes it "to be in the lower carboniferous measures, and to rest on the old red sandstone. The general dip," he says, "is southwards, and it seems not improbable that the coal strata are but the northern outcrop of a more extensive tract which lies concealed beneath newer formations towards the head of the Solway Firth." It seemed reasonable to suppose that the whole of the low country on the Solway Firth was a large coal basin, bounded by the red stone fault to the south, and the Scotch hills on the north. He understood that what appeared to be the outcrop of the lower coal measures had actually been proved on the other side of the Solway, as if forced up by the Scotch hills. Several holes had also been put down near Dumfries, one proving 8 inches of coal at 20 fathoms, and another bored 55 fathoms proving "very little red stone." He should like to ask Mr. Kendall whether he knew anything of a "basalt dyke" which was said to run "from Dumfries to Kirkbride, to the north of Wigton, and on to Armathwaite and Alston Moor"? Turning to the Whitehaven sandstone, he was inclined to ask the question—What is it? His own idea had always been that the term referred to a massive purple grey sandstone, more or less homogeneous, but varying somewhat in thickness, and of peculiar texture and colour. Professor Hull also seemed to adopt that meaning, for he describes it as "a massive reddish sandstone, 100 to 150 feet thick." The late Mr. Isaac Fletcher, too, he believed, held this view, and in his "Archæology of the West Cumberland Coal Trade," he speaks of it as a "purple sandstone, named by the officers of the Geological Survey the 'Whitehaven sandstone,' a full section of which is visible from the railway, a little to the north of William Pit." He also speaks of the Senhouse High Band being above it, not *in it*, as Mr. Kendall states. In his (Mr. Martin's) opinion, this massive post of sandstone forms the base of what may properly be called the Whitehaven sandstone series, and the existence below it of brown sandstones and shales—differing from it in every respect except the colour—does not prove that they belong to that section. It was also very remarkable with what regularity this massive post of sandstone existed throughout the district, where not

denuded. At Flimby Wood Pit, 7 fathoms below the Senhouse High Band, 17 fathoms 1 foot of what is called red post was passed through. At Ellenborough, 6 fathoms 4 feet 3 inches below the Senhouse High Band, 11 fathoms of what is called brown post was proved. At Croft Pit (Whitehaven) the thickness appeared to be 14½ fathoms; at Rosegill Pit (Crosby), 15 fathoms; at Aspatria No. 3 Pit, 7 fathoms; and at Mealsgate and Bolton the same massive post exists. In the thin beds of brown stone and shales found below this post of sandstone—and which Mr. Kendall assumed were part of the same series, there was no such regularity. They varied considerably in thickness in short distances, but seemed to approach nearer the lower coal seams, where the measures rose to the surface, or in the neighbourhood of faults. Then, as to the unconformity of this sandstone to the true coal-measures, he still maintained that it had not been clearly proved, and since the meaning of the term "Whitehaven sandstone," as adopted by Mr. Kendall, appeared so vague, he thought the case still more perplexing and doubtful. Of course it must be remembered that this phase of its character was introduced when it was supposed to be the local representative of the Permian sandstone. Theories were then started to prove this, and he need scarcely say that it was so proved, at least to the satisfaction of the originators of those theories. It had since been proved beyond doubt to be part of the coal-measures. Some of the theories upon which its unconformity had been based were proved to be unsatisfactory, and he, for one, was inclined to doubt—in part, at least, it would appear—its very existence. Again, what were they to understand by the term "unconformity?" In strata there was always more or less variation in the thickness of rocks and their relative depths. Many massive and well-defined beds of sandstone found to extend over hundreds of acres in one part of the district, were altogether wanting in another. He might mention the post of white freestone, 10 fathoms to 11 fathoms thick, lying above the Main Band Seam at Workington, which was not found above that seam in the new St. Helen's sinking, about half-a-mile to the north-east. No doubt this sandstone might be said to be unconformable, but it was not really so as that term is generally understood. Mr. Kendall had also attempted to prove its unconformity by showing that it nipped off the upper coal-seams in the direction of Mealsgate and Bolton; but this theory, though ingenious and clever, was not supported by facts. Taking Mr. Kendall's definition of the Whitehaven sandstone as being correct, and allowing all red or brown sandstones and shales to be reckoned as belonging to that series, he found, from journals in his possession, that not only was the theory incorrect,

but that in several instances there was an actual thinning of the red or brown measures to the east. In the Aspatria No. 3 air-shaft the last mention of brown strata is 66 fathoms above the Yard Band; the brown post, 7 fathoms thick, being 73 fathoms 3 feet 6 inches above that seam. At the Allhallows Colliery—about 3 miles east from Aspatria No. 3 Pit, and 500 or 600 yards north of Bolton No. 2 Pit—and which he believed to be sunk on the outcrop of the Whitehaven sandstone proper, red and brown sandstone and shales were found in the first 25 fathoms, but no massive post of brown stone. This showed the red or brown measures to be 80 fathoms above the seam supposed to be the Yard Band. Of course, he admitted that at 39 fathoms there were 3 fathoms or 4 fathoms of grey freestone, with fine red metal partings, almost like red ironstone bands; but the joints were very open and a large feed of water running, so that very probably the partings had been dyed. At the Bolton Company's No. 7 borehole, three-quarters of a mile further east from Allhallows Pit, with the exception of 5 feet of red clay about 13 fathoms from the surface, there was no red or brown measures, and the Yard Band was proved at 70 fathoms. At Bolton Low Houses, 3 or 4 miles east from Allhallows Colliery, the Main or Yard Band is still found in many places at a comparatively shallow depth; but had Mr. Kendall's theory been correct this seam too must have disappeared. Turning now to the Bolton No. 2 Pit, on the sinking section of which Mr. Kendall had, in a great measure, unfortunately, based his theory, they found that brown stones, etc., were found at 11 fathoms above the Yard Band, but, looking at the section of the No. 1 Pit, sunk over 300 yards to the east of the former, but in the same streak of coal, and without a fault of any kind between, he (Mr. Martin) found that the brown measures were 13½ fathoms above the coal. But supposing that all these facts could be set aside, did it not seem remarkable that in the place of the seams nipped off, other seams, identical in almost every particular, should take their places and maintain the same relationship to the lower seams? The thickening of the Whitehaven sandstone to the north is also equally unfounded, as can be proved by taking the Bolton No. 2 Pit section and the Allhallows section, or the section of the No. 2 Pit and that of the No. 7 borehole. In both cases a thinning rather than a thickening is shown. Mr. Kendall mentioned that the Whitehaven sandstone had been proved at Bolton to be 778 feet thick, and he (Mr. Martin) would like to know where and how it had been so proved. Was it by sinking or boring? Because if the latter, it must be received with suspicion, as he had found that the red water from the sides of a borehole, in the ordinary system of

boring, frequently dyed the borings before they were got out. Turning next to the seams of coal, the first met with was the Senhouse High Band, and it was a well-known fact that whenever it had been proved there existed below it a massive post of Whitehaven sandstone from 10 to 17 fathoms thick. Mr. Kendall supposed that the Crow Band of Bolton was the same seam; but in this he (Mr. Martin) thought he was clearly wrong. His own opinion was that it was below the Whitehaven sandstone, and taking the Allhallows sinking, and granting that the seam worked there was the Yard Band, and that the Thirty-inch Seam is the Crow Coal above the Main Band, the Master Band is found 20 fathoms higher, in the position of the Ten-quarter Seam—probably it is that seam: 14½ fathoms above, is the Crow Band, which may be the Slaty Band, and 6 fathoms higher still is a seam which may be the White Metal Seam. Above these again there are other small seams corresponding probably with the Brassy Band, and the other small upper seams of the west. The next of importance is the White Metal Seam, which, seeing that in some parts of the district there are other split-up seams within its range above the Ten-quarter, is sometimes difficult to identify. Generally, however, there is, about a fathom below this seam, a small seam of about 1 foot thick, commonly known as the Little Coal. The White Metal Seam corresponded, he thought, with the Cannel Band of Hope Pit, Workington, 20 fathoms above the Moor Banks or Ten-quarter; the Metal Band, 12 fathoms above that seam, probably being the Slaty Band. The Ten-quarter Seam, though variable in quality, thickness, and number of metals, is almost universal over the district, and had generally been considered the seam next in importance to the Main Band. He agreed with Mr. Kendall in the correlation of the Five-feet Coal of Cleator Moor with the Ten-quarter, and also of the Bannock Band of that district with the Rattler Band of the districts further north. Between 1 and 2 fathoms above the Main Seam was found what was called the Crow Coal, and except where the Main Band roof was freestone, this coal was pretty regular, though usually of inferior quality and unworkable. This coal Mr. Kendall supposed to be the Thirty-inch of the Bolton district, and supposing what was called the Main Band there was the Yard Band of the west; this probably was so. As regards the Main Band there was, he thought, so far as the western portion of the district was concerned, little room for doubt. It varied considerably in section, but generally the character of the coal was well maintained. There was a very remarkable change going eastwards, and at Bullgill the seam appeared to be very much split up, but seemed to be traceable in what are called the Metal

and Cannel Bands of that colliery. Further east at Aspatria Colliery there was a very marked thickening of strata between the Yard Band and the Thirty-inch, the distance between the seams being over 30 fathoms, and the supposed remains of the Main Band are not so clear. He thought it would have been interesting and instructive had they had before them sections of the Yard Band at Bullgill and Aspatria to show the thickening of the seam to the east. Mr. Kendall said the Mealsgate Seam was certainly not the Main Band of the west, but it must be remembered that it had many features in common with that seam. It was almost similar in section to the Main Band on Greysouthen Moor, and also, he believed, at Oatlands; its coal was of similar character and quality; it had not been proved in anything like an unbroken line, and, so far as he was aware, there was no appreciable change going eastwards either at Bullgill or Aspatria. They must also remember that the term "Yard Band" was an importation into the Bolton district, and had been pitchforked over first one large barrier and tract of unproved ground and then another until it had arrived at Mealsgate. He did not say it was not the Yard Band—he might have the impression that it was—but he thought it had not been clearly proved, and he would like very much to see that done. As regards the Little Main Seam he also thought that the section given by Mr. Kendall was somewhat misleading, but he agreed generally with what was stated in the paper respecting this seam. The Six-quarter Seam, to which Mr. Peile had given such an excellent character, was a seam which varied considerably both in thickness and quality. There was no regular thickening of the seam in any direction, as Mr. Kendall supposed, and so far as the district to the north of Whitehaven was concerned, and with which he (Mr. Martin) was more intimately acquainted, the general thickening seemed more in an easterly than a westerly direction. As Mr. Fletcher had stated the thickness of the seam at Melgramfitz was 5 feet 7 inches and not 2 feet 11 inches as Mr. Kendall stated, and all over the Greysouthen district the seam had been proved to be of good thickness; but at Camerton Colliery, to the west, only the top coal is found, being about 2 feet thick. At Jane Pit, Workington, it was 6 feet 11 inches, having 4 feet 10½ inches of clean coal; to the east of this pit it was worked free from bands of dirt, and about 4 feet thick, and a borehole was put down from the Union Pit workings to the west of Jane Pit, which proved it only 1 foot 6 inches thick. In the Annie Pit, close to the Jane, but separated from it by a 20 fathom fault, it was also found of good thickness. To the north of that pit a section was taken as follows:—Top coal, 2 feet 1 inch; metal, 1 foot 10 inches; bottom coal,

2 feet 1 inch; making a total working of 6 feet. To the south of the pit, however, the section of the seam was as follows:—Top coal, 2 feet 2 inches; metal, 1 foot 3 inches; coal, 1½ inches; or a total of 3 feet 6½ inches. The depth from the position of the Main Band at Jane Pit to the Hamilton or Six-quarter is 60 fathoms, though usually it is only about 40 fathoms in other parts of the district. This thickening of strata between the two seams, taken in conjunction with a thinning of the strata between the Hamilton and the seam proved at Hope Pit, which is supposed to be the Four-feet, had led some to doubt whether the Hamilton Band was really the true Six-quarter after all. The Four-feet Seam had been proved over a fault in Hope Pit, Workington, to be 24 fathoms below the Hamilton, 3 feet thick. The Virgin Seam, or what he (Mr. Martin) believed to be the Udale Seam, had also been proved at Jane Pit, Workington, about 50 fathoms below the Hamilton, and nearly 6 feet thick. Mention had been made of the Isabella Pit nip, and it certainly was interesting, because, unlike most other nips that had come under his notice, the seam regained its normal thickness by a succession of steps, as though the seam had been washed out by a running stream of water which had subsided somewhat suddenly at different periods. The Isabella Pit was sunk to the position of the Main Band at 128 fathoms, but the seam itself was entirely nipped of. The pit was sunk to a total depth of 131½ fathoms, and a borehole put down 4 fathoms 2 feet 5 inches further to what is called the Fiery Cannel, which satisfied Mr. Curwen and his engineers that the seam was nipped off. A drift was started away under the roof stone to the south-west till it cut the 13 fathom up-throw fault. It was then turned to the north-west and cut the Main Band at about 200 yards to the dip, at that point only 1 foot 4 inches thick. Ends were then driven water level, and after passing through several up-throw faults the seam was found its full height. The total width of this nip had not yet been proved, though the Main Band Seam, as had been proved by borings from the Moorbank's workings of John Pit, was found to be wanting for several hundred yards to the north. The new winning of the St. Helen's Company to the north of Workington would, no doubt, prove the width of the nip in that direction. The general dip of the Workington Colliery was north 14 west, and the average dip and rise 1 in 6.

Mr. T. J. Bewick said, that being unacquainted with the West Cumberland coal-field, he did not propose to say anything thereon, but with respect to coal being worked in the mountain limestone formation. Members of the Institute would recollect that there had been one or two papers written and published in the Transactions on the mountain lime-

stone coal. North of the River Tyne, it was worked at Blenkinsopp of considerable thickness; at Haltwhistle, and at Fourstones, where Mr. Benson worked it extensively. It was worked at Acomb, near Hexham, and northwards near Rothbury, and in the opposite direction, at several places in Allendale, and at Hawes in Yorkshire. This covered a great extent of district, and there was no doubt of its being the same seam over the whole area. As to coal occurring in the millstone grit, there was only one instance he knew of, and that was at Tanhill, south-east of Kirkby Stephen. This is near the summit of the mountain range at the head of Swaledale, where there are two pits, called the William Pit and the King Pit, and the coal is carried down the dales for the use of the people, and for smelting ore into lead. This is the only instance known to him of coal being worked in the millstone grit.

The PRESIDENT asked if in the instance mentioned by Mr. Bewick the coal was absolutely proved to be in the millstone grit?

Mr. BEWICK—Yes; he believed it to be so; it is above the limestone formation, the coal-measures are not known to exist there, and he had always understood it to be in the millstone grit. He did not know the thickness of the seam, but it was worked pretty extensively for land-sale. At page 351 Mr. Kendall stated that "It is no uncommon thing to find a dislocation of 40 or 50 fathoms dying out altogether within a quarter of a mile." He asked Mr. Kendall, and other gentlemen present, if this was a well-proved or well-known fact. It seemed to be so incredible that a fault of 40 or 50 fathoms should die out within a quarter of a mile that he could scarcely believe it. At least, in his own experience he had not found it so.

Mr. VIVIAN said he might inform Mr. Martin that a little gypsum was found in the sandstone at St. Bees, and the Whitehaven sandstone was proved at Kelsick Moss down to 1,040 feet.

Mr. C. J. CROUDACE, in reply to Mr. Bewick, said he could say from his experience that in one colliery in the district a fault of 42 yards ran out entirely in a distance of half a mile.

Mr. FLETCHER said, he could mention a case still more in point. At Melgramfitz Pit, the coal-field was bounded by an up-throw fault, which, in the valley of the Derwent, could not be less than 200 to 250 fathoms. A mile to the south the fault had been set-through, and absolutely proved to be no more than 40 fathoms, so that from 160 to 200 fathoms was run off in the course of a mile. There was, of course, only one explanation for it: on one side the strata dipped to the north and on the other side to the south.

Mr. JOHN DAGLISH said, he had met instances of this. There was a fault in the Harton Pit running out quicker than this. There was a fault in the Silksworth Pit, about 40 fathoms, which ran out in about half a mile. In these cases, the strata on one side generally rose and the other dipped, and they thus got a large throw in a short distance.

Mr. DAVID BURNS said, he would ask Mr. Kendall where he placed the limit of the millstone grit under the coal-measures, and whether there was any evidence that the coal-measures were lying conformably on the millstone grit? It seemed around the district of the lakes, in every geological period, there had been a great deal of commotion and change of circumstances, so that no bed seemed to be constant in character or thickness to any considerable distance. Mr. Kendall need not think less of them, therefore, if they criticised his correlations of these beds very much, nor need they think less of Mr. Kendall if he found it necessary in the future to alter them. Looking at the section of the lower portion of the Cumberland coal-measures, so far as he was acquainted with it, he would say, from a pretty intimate acquaintance with the millstone grit of the Newcastle coal-field, that the Yard Seam of this coal-field was about the same thickness as the Brockwell of Newcastle. As to the presence of coal in the millstone grit, he might say he had seen coal under each of the three beds of the millstone grit of the Newcastle coal-field, varying from three to eighteen inches in different parts; but they were very inconstant.

Mr. ROBERT WILSON said, that at his colliery, Broughton Moor (Bertha No. 2 Pit), he thought it was not the proper Six-quarter Seam which was opened, but probably the seam below, which was not a good coal. Where they expected the Six-quarter they got only one inch of coal and a sill. They had sunk and bored lower still. As to the large barren tract in the centre of the district, they worked to the south side of their Robin Hood Pit on Mr. Curwen's land, in Flimby, till the coal was washed off apparently; it was not just a nip in strata doing away with it. At one part it seemed in steps; and when it got on to the cannel, which was harder, it ran a long way. In one place there were two cannels, one lifted on the top of the other, and this was conclusive proof that it was the action of water. The roof in all places where the wash off occurred was white freestone.

Mr. KENDALL replied on the discussion. He said he was very much pleased that there had been such a large amount of *destructive* criticism, for it showed at least that considerable interest had been taken by some of the members in the paper. But he would have liked to see a little more *constructive* criticism. He thought he would be able to prove the

erroneous nature of the more important criticisms and maintain the conclusions at which he had arrived in the paper. Mr. Fletcher was right as to the section of the Little Main Seam at Aspatria. Instead of being as in the journal, p. 337 of the paper, it should be as below:—

	Ft.	In.
Coal		2
Rattler and splint	1	0
Coal	1	0
	2	2

He did not, however, think that anyone would be misled by this. If so, he might warn them that there are other places in the paper where only the full thickness of seams are given, the word coal in the journals standing only for coal-seam, except where a section was given clearly. Mr. Fletcher was also right as to the thickness and the section of the Lickbank at Melgramfitz. The remaining and more important criticisms of Mr. Fletcher he considered to be altogether wrong. If Mr. Fletcher would look at the paper again in connection with his remarks as to the Thirty-inch Seam and the Crow Coal, he would find that he had quite misunderstood the paper.

Mr. Croudace—Asked what depth was shown in Mr. Kendall's section between the Yard Band of Aspatria and the Thirty-inch?

Mr. Kendall—About 35 fathoms at Aspatria, No. 3 Pit.

Mr. Croudace—It is really about 160 feet. It has been proved at Brayton, No. 2 Pit.

Mr. Kendall—The seam which is usually called the Thirty-inch in the Aspatria district is not the equivalent of the Thirty-inch of Bullgill, but of the Metal Band as there named, and the 35 fathoms just mentioned is the proper Thirty-inch.

Mr. Fletcher repeated the opinion he had expressed before, that the Thirty-inch Seam at Mealsgate does not represent the Crow Band at Ellenborough and other places, but the Black Metal Band of the Clifton and Greysouthen district.

Mr. Kendall said, that he had not mentioned anything in the paper about the Thirty-inch of Mealsgate. What he said was, that the Crow Coal at Ellenborough was the equivalent of the Thirty-inch of Bullgill. The next point raised by Mr. Fletcher was as to the Lickbank at Greysouthen and Broughton Moor. It was admitted by Mr. Wilson that they did not claim the seam at Broughton Moor to be the same as the Lickbank of Greysouthen, and clearly they were two different

seams. Whether they took the depth below the Cannel and Metal Band, or the section of the beds, or the succession of seams, or anything else, it was quite clear that the one seam was not the correlative of the other, and that the so-called Lickbank at Broughton Moor corresponded with a seam at Greysouthen which was some fathoms below the Lickbank there. This agreed with what Mr. Wilson had said. They would find the same thing at Aspatria; the Lickbank there was lower than at Gilcrux, and corresponded with the Greysouthen Lickbank. An explanation which suggested itself to his mind was this: Mr. Steele (who, he believed, had managed both the Aspatria and Greysouthen collieries) probably gave the names to the seams, and in all likelihood he would give the same name to a seam in a corresponding part of the strata in different parts of the district.

Mr. WATSON said, there was a slight nip on the north side of Broughton Moor. The Lickbank was shown in the shaft a few inches thick, showing it was in the pit. As stated by Mr. Wilson, the seam below was not the Lickbank, it was called so in the section.

Mr. R. WILSON—It is called so in the section, but it is not so.

Mr. KENDALL—With reference to the China Band, the way he arrived at the correlation of that seam was by comparing the section of the Gilgarran coal-field with that of Greenspot and other collieries in the same neighbourhood. He found an exact correspondence in the beds at the different places, and the collieries were quite near together. At Gilgarran there are three seams, known as the Two-feet Coal, the Eighteen-inch, and the Yard. The Two-feet and the Eighteeen-inch are separated by about five fathoms of metal, and so are the Eighteen-inch and the Yard Coals. The same seams occur at Studfold, where the lowest is called the China Band. This seam he believed was the correlative of the Six-quarter of Whitehaven or the Yard Band of Gilgarran for the reason mentioned, that the Gilgarran and Studfold collieries were close together; and it was quite possible to make a correlation, almost bed for bed. The China Band at Oatlands Pit is doubtless the same seam as the China Band at Studfold and Greenspot; but he thought that Mr. Fletcher was quite wrong in saying that they had found the Bannock Band below the China Band at Oatlands, as it was really a small seam or rather two small seams lying between the Yard Band and the Four-feet Coal of Gilgarran, as the accompanying Plate V. will show. As regards Mr. Fletcher's observations on the nips at Workington and Camerton, he (Mr. Kendall) did not give a positive opinion on this matter in the paper; he only made a suggestion. The fact how-

ever of coal being worked, as mentioned by Mr. Fletcher, between the points where nips were met with, did not invalidate the suggestion made in the paper.

Mr. FLETCHER—But the nips are not continuous.

Mr. KENDALL said, he never suggested that they were, but simply that they might be parts of one original nip. He would next deal with Mr. Fletcher's remarks as to the seams in the Whitehaven sandstone. The conclusions drawn in the paper on this part of the subject are so novel and have such an important bearing on the question of the extent of the coal-field below the Permians in certain directions that it is well the conclusions should be thoroughly established. One of the speakers mentioned that in the new sinking at Flimby there was a red post sunk through some distance below the Senhouse High Band. He saw that himself, and was very much interested in it, and took copious notes of it at the time, and that really threw light upon the whole thing. They would find in examining sections of the Whitehaven sandstone at different places, that it was characterised by certain purple grey sandstones and shales. In boring and sinking journals this purple grey colour was entered as brown, purple, or red, according to the opinion of the borer or sinker, and this was to be borne in mind in attempting a correlation of these beds, from sections obtained by boring and sinking. At Rosegill Colliery, there were a number of red sandstones and shales, but intercalated with them there were a few light and dark coloured beds of shale corresponding with those of the lower coal-measures. At Ellenborough and Flimby there were more of these dark-coloured shales between the purple grey beds, and at Mealsgate exactly the same thing was found.

Mr. FLETCHER—In boring, mistakes are often made as to the colour of the strata. It is well known in the district that the coloured water of the red measures at the surface going down the hole colours the strata for many fathoms, and causes them to be entered in the journal as red.

Mr. KENDALL—That is quite impossible with a careful borer, as any colouring matter from the upper part of a hole would readily disappear when the sample was washed. Otherwise, in boring through soft smitty hæmatite, nothing but red beds would be found below, which is not the fact.

Mr. MARTIN—There is considerable difference between No. 1 Pit and No. 2 Pit. The journal of No. 1 Pit corresponds with the one given by Mr. Kendall, but the journal at No. 2 Pit shows red ground over 13 fathoms above the Yard Band. The Allhallows Pit was a sinking, and the notes were taken by a careful man.

Mr. KENDALL—He had had lithological sections made, and these showed both the argillaceous and the arenaceous beds. He had also made another lot of sections to show the colours of the different strata passed through. In this way he arrived at the line which he had marked as the base of the Whitehaven sandstone. There was a reddish post of sandstone below the Senhouse High Band at Maryport, which undoubtedly belonged to the Whitehaven sandstone, and there was the same post below the so-called Ten-quarter at Aspatria; and also, but much more split up, below the Master Band at Bolton, as shown on Plate VI. These were the main grounds on which he had based his conclusions as to the Whitehaven sandstone and its included seams, that there are certain beds having a certain colour, below the Crow Band and the Master Band at Bolton, which correspond with the bed, which, in his opinion, is below the Senhouse High Band, and another bed not worked at Ellenborough and Flimby. If this view were taken, the difficulty of correlating the Crow Band and the Master Band of Bolton with seams in the lower part of the coal-field would be overcome. He would be glad indeed if anyone present would show him how either of these seams, which he had put in the Whitehaven sandstone, could possibly be correlated with a seam in the lower part of the field.

Mr. MARTIN asked to what sinking at Aspatria Mr. Kendall referred. Was it the air shaft?

Mr. KENDALL—The section before the meeting is of No. 3 shaft.

Mr. MARTIN said, the air shaft was close to it, and in going carefully through the journal he found no mention of red, brown, or purple grey strata nearer than 66 fathoms above the Yard Band, whereas Mr. Kendall stated it to exist at 36½ fathoms above that seam.

Mr. KENDALL said, probably it might be entered as grey, for the purple grey of the Whitehaven sandstone might at times be so described by those who were not accustomed to nice distinctions of colour.

Mr. MARTIN—Between the Bolton Nos. 1 and 2 Pits, which are not far apart, there is a difference in the thickness of ordinary strata above the Yard Band of nearly three fathoms, and that in an opposite direction to Mr. Kendall's theory. He maintained that the beds had been coloured by the denuding wash from the Permian stone, and also the Whitehaven stone. They were not like the Whitehaven sandstone, but were different altogether.

Mr. KENDALL—It is a most extraordinary thing that the colouring should extend downwards at Bolton nearer the Yard Band than it does in the other parts of the district, if the colouring of these beds is due to

some process of staining which took place after the beds were deposited. That such subsequent colouring should affect impermeable argillaceous rocks at great depths seems impossible. If it had done so at Bolton why not in other parts of the district?

Mr. MARTIN—At Bolton Colliery the strata is at a greater angle than at Ellenborough, and it outcropped, and enabled water and colouring matter to percolate that could not have passed in the more horizontal and better protected beds at Ellenborough. That will explain the matter.

Mr. FLETCHER—The beds underlying the Crow Seam and the Master Band in Allhallows, which he (Mr. Fletcher) maintained are not in the Whitehaven sandstone, are not red.

Mr. KENDALL—They are not met with at Ellenborough until some depth is reached, and then the red beds come in. At Allhallows the equivalents of the red beds occur below the Master Band, but in the sinking journal they are described as grey, probably, for the same reason as the beds in Aspatria Pit, referred to by Mr. Martin, are not spoken of as red or purple grey. As shown in Plate VI. herewith, there is but a small thickness of reddish beds below the Master Band at No. 3 Pit, Aspatria, but in a borehole close to that pit, as shown in the section, there is the full thickness of reddish beds; and it cannot be said that they have been stained by colour from the upper part of the borehole, because there is not any red ground in the upper part of the hole. This section therefore disposes at once of the suggestion of Mr. Fletcher and Mr. Martin that these lower red beds are stained during the operation of boring.

Mr. FLETCHER—They are not conformable with the Whitehaven sandstone.

Mr. KENDALL—That is the point in dispute, but if Mr. Fletcher will travel beyond this unsupported assertion, it will be quite easy to show where he is wrong.

Mr. J. B. SIMPSON—Is everybody agreed that the Yard Band Seam shown in the different sections can be traced through?

Mr. FLETCHER—There can be little doubt that the correlation of the Yard Seam in the paper is correct, if what is called the Main Band at Mealsgate be the same seam.

Mr. J. B. SIMPSON—Are the quality and character the same?

Mr. FLETCHER—Yes, very much the same.

Mr. KENDALL, in answer to Mr. J. B. Simpson, said that in a paper "On the Hæmatite Deposits of West Cumberland," which he some time ago read before the Institute, it was stated that the thickness of the millstone

grit was found to be 450 feet at Parkside. What the thickness was below the coal-field he did not know, but he hoped to settle that matter in a paper which he was preparing on the correlation of the different members of the carboniferous system in Furness and West Cumberland.

Mr. J. B. SIMPSON—Mr. Kendall says that the red beds are uncomformable with the other measures. Take Ellenborough section. He would like to know whether these beds are lying at the same angle as those below. There is the Senhouse High Band; is it lying at the same angle as the Allhallow's Seam?

Mr. KENDALL—At Croft Pit the base of the Whitehaven sandstone is about 61 fathoms above the Bannock Band, and in the neighbourhood of Rowrah and at other parts of the district, this sandstone is down on the millstone grit. Surely there can be no better evidence of unconformability than this?

Mr. J. B. SIMPSON—There might have been denudation between the lower beds and the sandstone.

Mr. KENDALL—Agreed that it was denudation combined with tilting which had caused the unconformability. Difference in the inclination of seams is, in itself, not any test of unconformity. By reference to p. 336 of the paper it will be seen that the thickness of ground between the Bannock Band and the Main Band, increases from 9 fathoms at the St. Bees borehole to nearly 22 fathoms at Wellington Pit. There is thus a great difference in the inclination of these seams, but surely there is not anyone who would say they were unconformable, One point raised by Mr. Burns related to the downward limit of the coal-measures and the upward limit of the millstone grit. He would not like to say much about this at present. He had not gone into this question to a sufficient extent to allow him to correlate this coal-field with the coal-measures on the east coast. He would therefore not like to fix the base of the lower coal-measures, but it seemed to him that it did not affect the present question one iota whether they said the base of the coal-measures was below the Udale Band or above it. The most important thing, from the miner's point of view, was to have got the correlation of the beds. He knew some people held that the whole of the Whitehaven coal-field was not in the coal-measures at all, but was in the Yordedale rocks. That was however a matter on which he would not express an opinion, as its determination involved an amount of information which would take a considerable time to get up. In placing the coal-field above the millstone grit, as he had done in the introductory part of the paper, he merely adopted what appeared to be the most natural subdivision of the carboniferous system

of West Cumberland. But when he came to deal with the district in relation to the typical areas, it might, although he did not think it would, be necessary to modify this subdivision. In reply to Mr. Peile, he said that the statement in the paper as to the dip of the measures at Workington was quite correct, as could easily be seen at any of the outcrops. To Mr. Martin, he would say that the additional information asked for as to the Permians, would not throw any further light upon the question of the Sub-Permian coal-field. To go beyond the paper in this matter, would simply be to occupy time in discussing a subject with insufficient data. The miner or the borer, or both, have something more to do before there can be any further profitable consideration of this most important question. Mr. Martin says that Mr. Steele informed him that the rock cut beyond the great red fault from the Ten-quarter Seam at Ellenborough, was St. Bees sandstone. Mr. Steele is wrong about this, for the following reason: On the downside of this fault, and not far from the place where the fault was intersected in the mine, a borehole was put down from the surface and passed through a coal seam 1 foot 5 inches in thickness. It also intersected several beds of blue metal and of sandstone with coal pipes before reaching the depth of the drift put through the fault. These surely do not belong to the St. Bees sandstone, nor to any strata above it. There were numerous red beds recorded in the journal of the borehole, but clearly they were of Whitehaven sandstone. Mr. Martin appears to be in considerable doubt as to what the Whitehaven sandstone is, but he understands the term to refer "to a massive purple grey sandstone, more or less homogeneous, but varying somewhat in thickness, and of peculiar texture and colour," and that "this post of sandstone forms the base of what may properly be called the Whitehaven sandstone series." Mr. Martin then gives the thickness of what he considers the post at different places, but the whole of his remarks show that his ideas on the subject are in a state of the most perplexing confusion, as will presently be made manifest. Mr. Martin is unfortunate in adducing Professor Hull as an authority on the Whitehaven sandstone, for a very short perusal of the coal-fields of Great Britain by that writer, will convince anyone that he is practically unacquainted with the Cumberland coal-field. To understand clearly what is meant in the paper by the term Whitehaven sandstone, it is necessary to know that in the neighbourhood of Whitehaven, and overlying the lower coal-measures, there are certain patches of a purple grey sandstone, which has for years been known as the Whitehaven sandstone. The colour of this rock is quite peculiar, being altogether unlike that of any other

rock in the district. Another peculiarity of it is that in places it contains a large number of red irony nodules. In the cliffs at Bransty, and between Wellington Pit and Port Hamilton very good sections of this rock may be seen; and it is elsewhere exposed in the neighbourhood in numerous quarries. Sometimes the sandstone is nearly white or a very pale grey. For anything that is to be learned to the contrary from these natural sections, the formation consists entirely of a mass of sandstone containing a few thin beds of shale. But in sinking through it, as at Croft Pit and elsewhere, it is found that a larger proportion of it is shale than would have been supposed from an inspection of the outcrops alone. This, however, is only what might be expected, and is in accordance with general experience; soft shales seldom forming visible natural outcrops, except in stream beds, and there are very few streams of any size on the area of these beds near Whitehaven. It is therefore easy to understand how the earlier geologists who named this formation from a study of it as developed at Whitehaven, should be of opinion that it consisted mainly of sandstone, and should on that account call it the Whitehaven sandstone. But when the formation is studied in other parts of the district, as, for instance, at Flimby and Maryport, it is found to be different from what it is at Whitehaven. In the new pit at Watergate, near Flimby, a post of Whitehaven sandstone about 11 fathoms thick, was entered at about 13 fathoms from the surface. There could not be any possible doubt about its being the same kind of rock as that which is exposed in the cliffs at Whitehaven. Above this purple grey sandstone the rocks sunk through were of the ordinary coal-measure type, so were they below. At six fathoms from the surface, and therefore above the bed of purple grey sandstone, a coal seam, known as the Senhouse High Band, was passed through. These are the facts which led the late Mr. Isaac Fletcher to speak of the Senhouse High Band as being above the Whitehaven sandstone. From Flimby pass on to Maryport, where also the Senhouse High Band has been wrought, and where, too, the purple grey sandstone occurs below it. For a thickness of about 32 fathoms above the Senhouse High Band, the rocks are mainly of the ordinary coal-measure colour and character, and they include several small seams of coal. But above these rocks, purple grey sandstones and shales appear again, which are in all their essential characters exactly the same as the sandstone below the Senhouse High Band. For that reason they were included with the Whitehaven sandstone in the paper. At Rosegill and Crosby, the interbedded light and dark-coloured shales appear to be almost

absent, but they are seen again at Aspatria, although they are not quite so thick as at Maryport, as will appear by reference to Plate VI. They are also found at Mealsgate, where they have about the same thickness as at Maryport. About three-quarters of a mile north-east of Mealsgate station, the Crow Band (the equivalent of the Senhouse High Band) was found at a depth of 104 fathoms, and the first 58 fathoms were mainly purple grey sandstone; then followed down to the Crow Band, 39 fathoms of shales with thin coals and a few beds of sandstone. These were mainly of the ordinary coal-measure colour. At Bolton No. 2 Pit and in No. 5 bore at that place, the purple-grey sandstone was found to be below the Crow Coal, although it was there split up by shales, as shown in Plate VI. The Whitehaven sandstone may therefore be said generally to consist of purple-grey sandstones and shales, with which are intercalated at places shales and sandstones resembling the lower coal-measures, and which, like them, contain seams of coal. It has been seen that the colour-test plays an important part in the determination of the base of the Whitehaven sandstone. It has also been seen that the purple-grey colour which is one of the main characteristics of the formation is sometimes absent, and that the arenaceous beds are blanched or of a very pale colour. Bearing that in mind, it is extremely probable that the freestone beds just above the Ten-quarter Coal at Crosby, are the base of the Whitehaven sandstone; that they are, in fact, the equivalent of the purple-grey beds under the Senhouse Band at Maryport, and that they have been blanched. The two main seams above the Ten-quarter Coal there, would then correspond to the Crow Band and the Master Band of Bolton, as shown in Plate VI. That being so, the base of the Whitehaven sandstone, as shown at Bullgill in Plate XXXIII. (Vol. XXXII.), and at Crosby and Gilcrux, on Plates XXXIV. and XXXV. should be lowered. The same considerations would similarly affect the position of the base of the Whitehaven sandstone at Whitehaven and Cleator Moor. At Croft Pit, for instance, the white sandstones which occur about 40 fathoms above the Bannock Band may be taken as the blanched or unstained base of the Whitehaven sandstone. Above this are seams which would correspond to the Crow Band and Master Band of Bolton. At Cleator Moor, the base of the formation, on the same principle, would be placed at a post of white sandstone about 30 fathoms above the Bannock Band, and therefore below seams corresponding to the Crow Band and Master Band. This is almost certainly the correct rendering of the facts; but it will seem so outrageous to anyone who is accustomed to look at a part of the field only, that it requires all the courage of firm

conviction to suggest it. With these additional observations, the Whitehaven sandstone formation may generally be considered to have the following section where it is complete.

Purple-grey sandstones and shales, with occasional light and dark-coloured shales. The sandstones sometimes blanched or unstained.

Light and dark-coloured shales, with numerous thin seams of coal, and two workable seams; also a few beds of sandstone.

Purple-grey sandstone, sometimes blanched or unstained, and in places split up by shale.

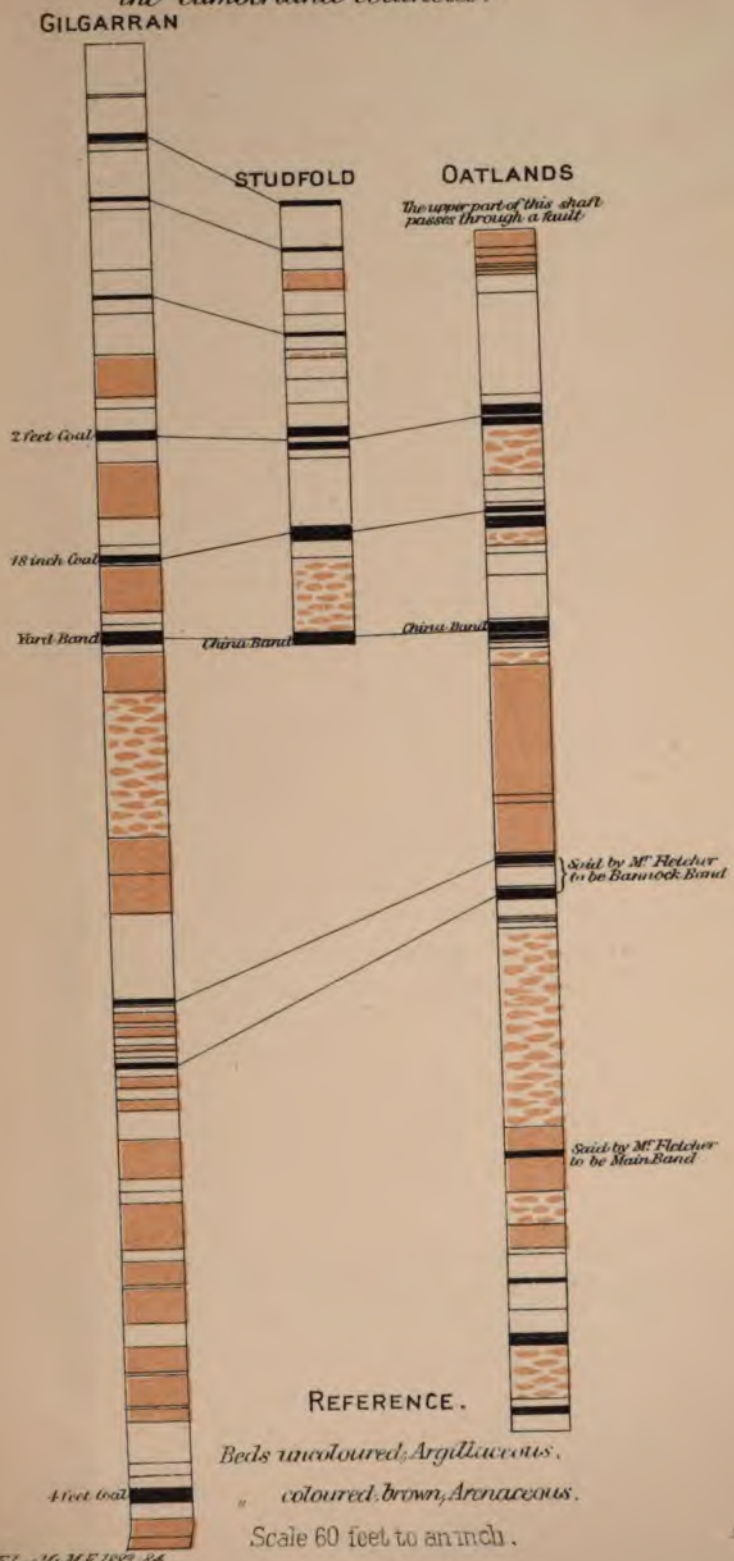
If the sections on Plate XXXIII. of the paper be correlated on this principle, they would be as shown on Plate VII. herewith, whereon all the workable seams of the field are correlated, and in the small upper seams order is introduced where previously there was somewhat of confusion. Another matter about which Mr. Martin seems to be undecided, is as to the meaning of "unconformity." This seems almost incredible, for although there may be at times the very greatest difficulty in determining an unconformity, there cannot surely be any doubt in the mind of a geologist as to what is meant by the term. Mr. Martin's illustration, drawn from the change in the character of the strata overlying the Main Band at Workington and St. Helens New Colliery, is altogether beside the question. If there is one fact better impressed than another on the mind of a field geologist, it is that beds of sandstone very often alter into beds of shale. Again, Mr. Martin says that "at Bolton Low Houses, three or four miles east from Allhallows Colliery, the Main or Yard Band is still found in many places at a comparatively shallow depth; but had Mr. Kendall's theory been correct, this seam, too, must have disappeared." This statement can only have been made because Mr. Martin has failed to grasp the theory. Bolton Low Houses is much farther to the dip of the field than Bolton No. 2 Pit, and the effect of that will be readily understood by reference to Plate XXXIV., Section 6, of the paper, where it is shown that higher seams come on to the dip, and therefore, although the seam would be cut off where the Whitehaven sandstone comes down upon the strike line of Bolton No. 2 Pit, if produced eastward, it would not be so cut off at Bolton Low Houses, because that point is to the dip of such strike line. Another remark of Mr. Martin's must be noticed: he says, "turning now to the

Bolton No. 2 Pit on the sinking section of which Mr. Kendall had, in a great measure unfortunately based his theory," &c. Where did Mr. Martin get this information? It is true that is the only section in the Mealsgate district which is given in the paper, but it must be borne in mind that the paper is only a summary of the conclusions which were arrived at in the investigation of the coal-field. Not one-twentieth part of the information used in arriving at those conclusions appears in the paper, as it was considered better to give as little as possible beside the bare results, rather than bury the conclusions in innumerable details. These, however, are ready at call to support the conclusions set forth. Mr. Martin may rest assured that the theory was not based on any single section, but on a very large number of sections, and only after travelling, hammer in hand, many hundreds of miles. General conclusions regarding complicated phenomena are not to be reached by the study of a single fact, or even of a few particular facts. Mr. Martin in his correlation of the seams in Allhallows Pit, ignores all the principles of stratigraphy, as will be seen on reference to Plate VI., in which Mr. Martin's correlation is indicated by blue lines. Mr. Martin says that the Main or Yard Band at Mealsgate is the same in section as the Main Band at Oatlands. If Mr. Martin will look at Plate V. herewith, he will see that they have not got the Main Band at Oatlands. With regard to the identity of the Main Band of Bolton, Mr. Martin may soon satisfy himself that it is the Yard Band, if he will carefully compare the sections obtained at Aspatria, Blennerhasset, and Mealsgate, which probably he possesses. Mr. Martin has put a meaning on the statement in the paper with regard to the westerly thickening of the Six-quarter Seam, which it was not intended to bear. It is quite clear that the statement was not meant to exclude the northerly or southerly attenuation of that seam, from the fact that the Three-feet Coal at Harrington was said to be the same seam.

The PRESIDENT said, the long discussion which had taken place and the information which had been given showed the great interest taken in Mr. Kendall's paper, and proved the desirability of members having an opportunity of discussing papers affecting their own districts.

The meeting concluded, and the members were entertained to luncheon by the traders of Workington.

Illustrate the discussion on Mr. J. D. Kendall's paper "On the structure of the Cumberland Coalfield."



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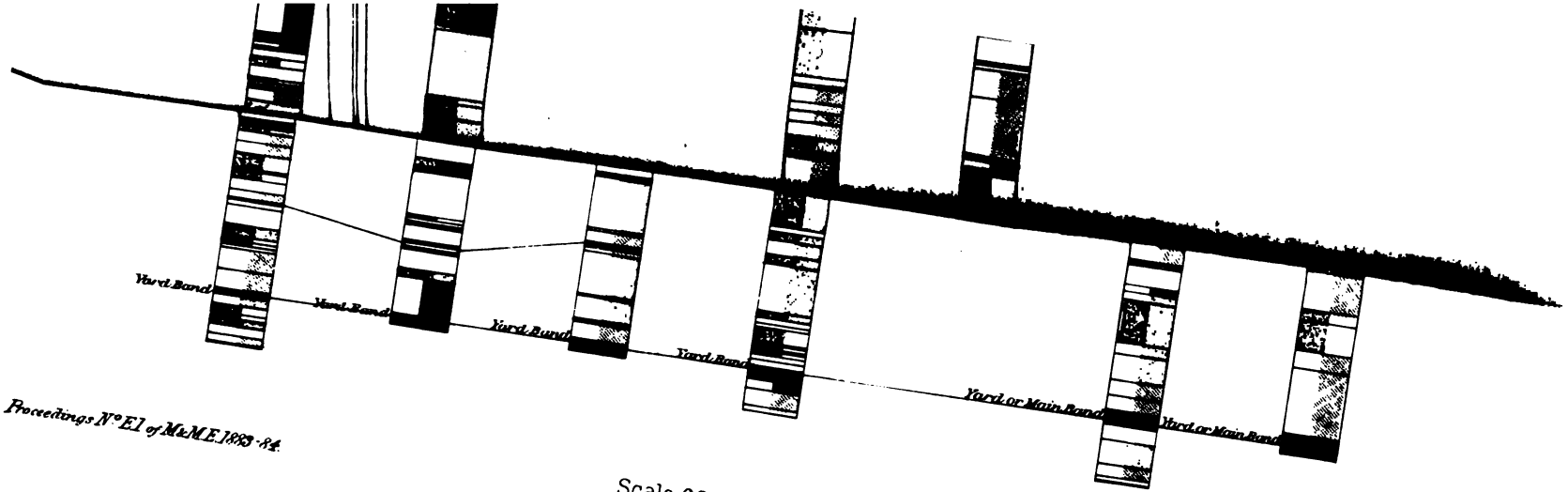

Proceedings N° E1 of M.M.E. 1883-84.

Scale 60 feet to an inch.

Ard Ted Fenwick.

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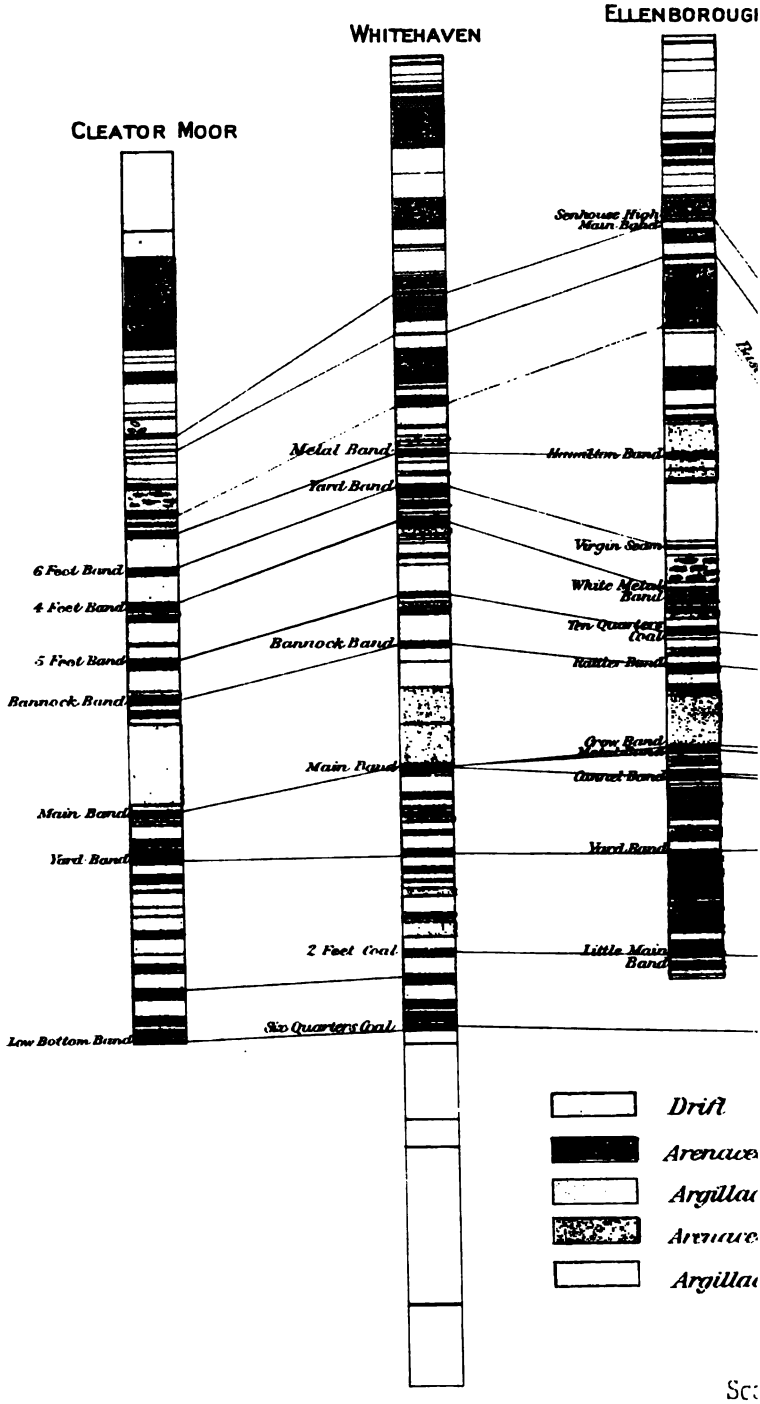
To illustrate the discussion on Mr. J. D. Kend



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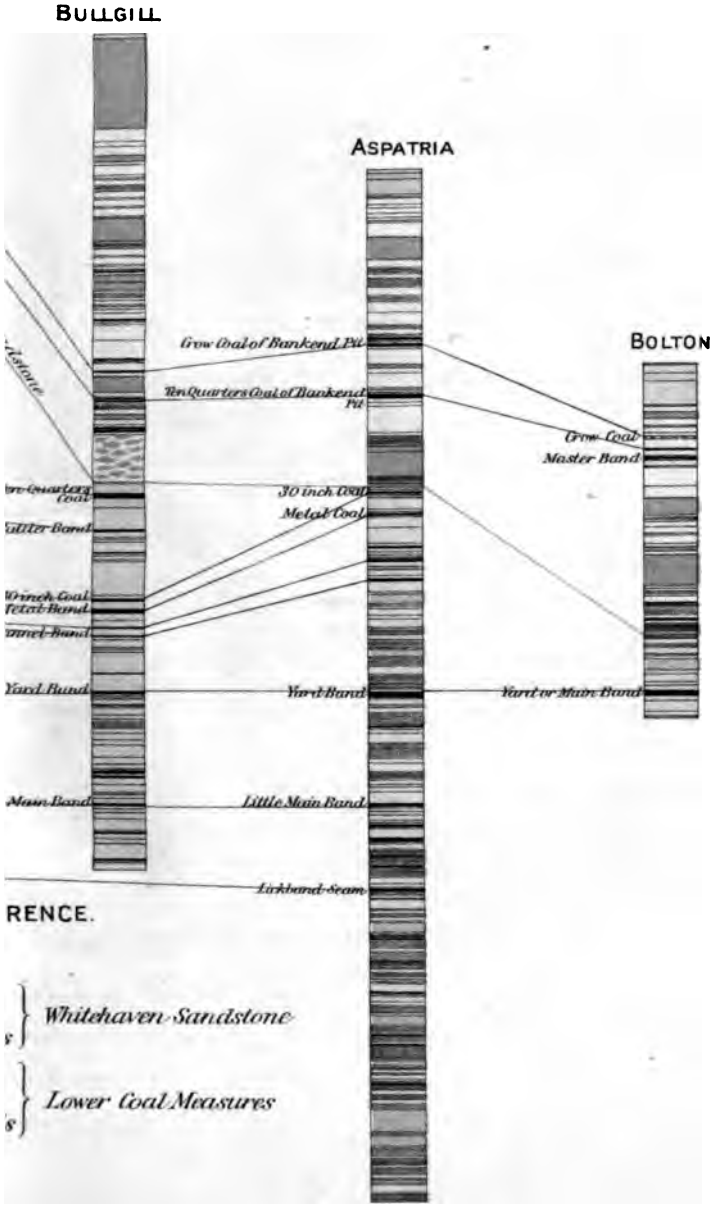

PROCEEDINGS.

GENERAL MEETING, SATURDAY, APRIL 12TH, 1884, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

GEORGE BAKER FORSTER, ESQ., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting and reported the proceedings of the Council.

The following gentlemen were elected, having been previously nominated:—

ORDINARY MEMBERS—

Mr. JOHN JAMESON, Consulting Engineer, Akenside Hill, Newcastle-on-Tyne.

Mr. BENJAMIN JAMES FORREST, Mining Engineer, Calle de ras Infantas No. 18, pº. 3º., Portugalete, *via* Bilbao, Spain.

Mr. J. C. FORREST, Witley Coal Company, Limited, Halesowen, near Birmingham.

Mr. WILLIAM ASSHETON CROSS, Messrs. R. & W. Hawthorn, Newcastle-on-Tyne.

Mr. WM. COCHRANE said that, as the attendance at the meeting was so small, he proposed that Mr. Melly's paper, "Notes on the Warwickshire Coal-field," be taken as read, and the meeting be adjourned.

Mr. A. L. STEAVENSON seconded the motion, which was agreed to, and the meeting was adjourned accordingly.

NOTES ON THE WARWICKSHIRE COAL-FIELD.

By E. F. MELLY.

This Coal-field is the smallest in England, next to the Forest of Dean, and extends only from Coventry to Tamworth, a distance of 18 miles, the average width of proved workable coal being about four miles. The accompanying Map, Plate VIII., shows that the coal-measures are but slightly seen on the surface, and that the line of outcrop passes along the villages of Longford, Chilvers Coton, Atherstone, and Polesworth on the east, while the boundary line of the coal-measures on the west, or rather the point where they dip under the Permian, runs through the villages of Bedworth, Stockingford, and Baxterley. A large area of coal may be worked under the Permian, and, as shown in the sections, the seams appear to become flatter, but after three miles or thereabouts further progress in this direction is stopped by a fault running nearly north and south. The northern boundary is simply a large down-throw fault running north-east by south-west.

To further illustrate this Plan, two sections (Plate IX.) from the Geological Survey are here given. They show in all five seams of coal, and in both cases, their boundary is the outcrop on one side and a large fault on the other.

SEAMS.

There are not very many seams in this county, but they vary very much in thickness, in depth, and also in the thickness of the strata lying between them. The following is a list of the coal seams which have been and are now being worked, with the sections at some of the collieries now working them. The section is occasionally much thicker.

	Ft.	Ins.	
Four-foot Coal	4	6	not worked any longer.
Two-yard Coal	6	0	
Bare Coal	2	0	sometimes worked with Two-yard, there being a small parting between them.
Rider Coal	4	0	
Ell Coal	4	0	
Slate	6	6	
Seven-feet	5	9	
Bench Coal	6	0	very little worked.

From this section it will be seen that these seams of coal are all of a good thickness, and in each case the section is fairly clean and free from dust partings, except the Four-feet and the Bench coals, but almost all of them are spoilt by an undue proportion of iron pyrites.

They lie at a considerable inclination, which dips chiefly due west, varying from 1 in 5 to 1 in 6, but they appear to be fairly regular, although from the southern to the northern point of the coal-field the strata between them gradually thicken out, and they gradually get further and further apart from each other. Thus, at Hawkesbury Colliery, the total thickness from the top of the Two-yard coal to the Seven-feet is 22 yards, while at Griff Colliery, about four miles north, the total thickness is no less than 60 yards.

To illustrate this a further section is extracted from the Geological Report, and is shown in Plate IX.

It would seem that coal has been worked in Warwickshire from a very early date, but the writer has not been able to find any reliable records of its being worked before 1600.

The evidence on the surface at the present time of the very numerous pits, most of them not more than six feet in diameter, points out distinctly that mining was carried out in anything but an economical fashion. Besides coal, both limestone and ironstone were worked, the latter until 1868, when it was superseded by the use of the cheap Northamptonshire ore. It may be remarked that on an estate of only 500 acres there are no fewer than 23 pits which have been sunk to work one or other of the seams, and in some cases the ironstone, and of which only five now remain open. Until quite recently it was customary to sink a pit, put down small machinery, and work out a few hundred yards of coal on each side, most of which was sent away by canal, and then abandon it. In a few cases coal has been worked out by means of an open drift from the outcrop, but, at the present time, there is hardly a colliery in the whole of Warwickshire which has any coal left to work, except to the dip.

The Inspector's Report for 1882 gives the number of collieries at work as 16, and all of these are still at work.

Table I. shows the output for the last two years, and also the average tonnage drawn per day at the collieries, allowing 250 working days per annum. It will be seen that this figure is not very high, the largest colliery in Warwickshire producing, in fact, only about 450 tons per day from one pit. It also shows the number of deaths which have occurred in the same time, and the tons of coal raised per death.

TABLE I.

Year.	Collieries in Warwickshire.	Tons Raised.	Persons Employed.			Tons Raised per Man per Annum.	Total Deaths by Accident.	Tons of Coal Raised per Death.	Average Output, allowing 280 working days per Annum.
			Surface.	Underground.	Total.				
1881	18	1,133,419	999	3,235	4,234	268	4	283,354	252
1882	16	1,066,741	1,007	2,993	4,000	266	26	41,029	266

Taking the year 1881 as an average year of deaths by accident (the whole deaths in 1882, besides the fatal Baddesley explosion, being only three), the number of tons raised per death in Warwickshire compares favourably with the figure of 177,106 for the United Kingdom in 1881.

The average work done per man, as shown by the tons raised per person employed per annum, is very much less than in the United Kingdom, which for 1881 is no less than 311 tons. This may perhaps be partly due to the very slack working at most collieries in the district during the summer months.

FAULTS.

This coal-field appears to be singularly free from faults, except the large ones, which practically form its boundary; but the writer has recently met with two small down-throws, each of about 4 feet 6 inches, which appear to run out to nothing in a distance of a few hundred yards, while the coal is in no way deteriorated in quality right up to the fault on both sides, except that the section appears to get thinner and somewhat harder.

GAS.

These coal-seams appear all of them to be remarkably free from gas, and all the collieries in this district are universally worked with candles. This makes it all the more difficult to account for the serious explosion at Baddesley Colliery in 1882. At a colliery, well known to the writer, working three of the above seams of coal, no gas has been reported in any part of the colliery during the last five months.

WATER.

The great amount of water which has to be dealt with by nearly every colliery in the district more than balances the advantages accruing from the immunity from gas.

The strata above the Two-yard Seam appear to be many of them very porous with the exception of the clay on the top, and large quantities of water evidently find their way through the breaks near the outcrop; moreover, in past years the outcrop of the upper seams has been very thoroughly worked, and the water finds its way out of the old workings into the present pits sunk further to the dip. Besides this, the water drains through the surface soils further to the dip, and these being the Permian measures, they are no doubt specially porous.

The writer has, during the past year, diminished the quantity of water at one colliery by about one-third, by having the surface drains properly cleaned out and all signs of cracks carefully puddled.

A further proof of the open character of the strata is the fact that the effect of heavy rains is felt in about ten days in the workings, and this is shown by the increased pumping required.

Another circumstance which contributes to this is the fact that many of the owners of brickworks in the neighbourhood have, in past years, indulged in a practice of sinking small wells, 3 or 4 feet in diameter, down to a stratum which is known as the Four-foot stone, and which is of so porous a nature as to be capable of adequately draining the whole of the accumulation of the clay pit. This water, of course, eventually finds its way into the adjacent collieries.

At one colliery in Warwickshire, no sooner have new workings been opened out in the Two-yard Seam (which, it will be remembered, is nearest the surface) than with the first heavy break of the roof an enormous inundation of water has each time occurred. The quantity varied from two to three hundred gallons per minute, and continued running sometimes for several weeks, and only ceased when work had been recommenced and the face had proceeded several yards; and, curiously enough, when the outburst has once occurred and ceased, the workings in the district frequently go on for years without being further affected. It appears as if the Four-foot stone before mentioned accumulates this large quantity of water, which breaks through at the first opportunity and then runs itself off.

SPONTANEOUS COMBUSTION.

The principal distinctive feature about the Warwickshire coal-seams is the fact that they are one and all very liable to spontaneous combustion. There are, of course, several explanations of it in the district, but it is no doubt in great measure due to the heating of the pyrites (which, as has been before stated, is in large quantities) with the small coal which has been thrown back into the goaf.

It is also said that the clay under the coal is one of its greatest promoters, and many of the old colliers refuse to hole in it for this reason, preferring to hole in the harder coal as being safer. The writer is, however, sceptical as to this clay being the cause, and where the holing is cheaper in it than in the coal, would always run the risk and hole in the clay.

The conditions most apt to produce an underground fire appear to be slight dampness and plenty of air, the warm return air being, of course, worse than the intake air. These fires rarely occur near the face, but always at some distance in the goaves, and almost invariably close to the packed side of a wind road by the side of longwall working. It is, therefore, not considered safe to have such wind roads more than about 30 yards in length, but to drive a small coal road with a pillar of 5 yards from the workings, and to hole through into this every 20 to 30 yards. At one of the collieries in this coal-field no less than four underground fires, more or less serious, have occurred in eighteen months.

The first indication of a fire is a peculiarly offensive smell of burning, having a slight likeness to that of sulphuretted hydrogen, and steps should then be immediately taken to keep the fresh air from approaching the spot. If it is possible to divert the course of the air and at the same time to approach the fire, dams should be constructed immediately with about 3 feet thickness of sand, and then a brick wall to keep this in, and the whole district of the fire cut off in this way. Unfortunately, however, a fire generally occurs in the return air-way from a set of workings, so it would probably be necessary to sacrifice these workings until a new air-way could be driven, as the air must for the meantime be diverted down the working road and kept entirely clear of the site of the fire. Another method, which should, however, be only a temporary one, has been tried with some success. While another air-way was being driven to clear the site of the fire by several yards, two brick stoppings were put in at each side of the fire at a distance of 6 yards, and three sets of 12-inch air-pipes were built into them, the whole of the interior between the dams being filled up with sand. In this way the air was cut off from the fire without stopping the ventilation of the workings.

As a rule, however, there is no excuse for this, as even in a good current of air there will be several days warning, after the "firestink" (as it is called) is first detected, before it developes to such an extent as to make it absolutely necessary to dam off the place.

The writer was obliged, a few months ago, to open out a whole district which had been "stanked off" (as the phrase of the district is) for over a

year, and on approaching the old air-way the heat became intolerable and the fire was burning as badly as ever. A new air-way was, however, driven within a few yards of the old one, and as soon as the heat permitted, the old air-way was opened and at every stenton a dam of sand was put in. By dint afterwards of lining the whole goaf at the working face with sand, the fire was successfully passed, and has since become extinct. It may be added that no material is found to suit the purpose of damming off the air so well as the sand, clay being by no means so good.

COLLIERIES.

The general aspect of a Warwickshire colliery does not show great promise in comparison with the larger collieries of South Yorkshire, Lancashire, and the North of England. It is very unusual to find the shafts more than 9 feet in diameter, and these have in many cases been sunk by untrained men, and great trouble has in consequence occurred in shaft repairs, to say nothing of the fact that many of these shafts have been sunk out of plumb and in some cases are only cased with dry brick. This is, of course, due to the old system of working only small areas to one pit. The shafts are, as a rule, fitted with a double-decked cage, holding one tub on each deck, and the guides employed are almost invariably wooden guides, 5 inches by 3 inches, made of pitch pine and secured to buntons fixed in the shaft sides every 6 feet.

GENERAL PLANT.

The general plant of a colliery is also of anything but modern construction. The boilers are generally the old egg-ended ones and of very large diameter, and the winding engines are chiefly vertical and of somewhat ancient construction.

TIMBER.

The consumption of timber in all the seams except the Seven-feet is remarkably low, and at one colliery with which the writer is acquainted is as low as ¾d. per ton for the Slate coal and Two-yard. In the main roads larch is generally used, but the Warwickshire colliers are by no means expert in timbering, and the fitting and nicking of a set of timber is seldom properly done. Where, however, the inclines and roads have been carefully driven and sufficient coal left overhead and underfoot, they require very little doing to them.

TUBS.

The tubs generally used are very small and not as a rule more than 18 inches deep. The consequence is that they only hold from 6 to 8 cwts. of coal.

DIVISION OF COAL.

The coals produced are generally in very large lumps, but are not selected in the pit, except in special cases. They are all filled by hand, and as very little slack is made in working the coal, it rarely amounts to more than from 7 to 8 per cent. of the whole output sent to bank.

Screens are of comparatively recent introduction in this district. It is usual to handpick the coal from each seam, the best house coals being, as a rule, carefully packed to prevent breakage; thus, the pit top is generally laid out on the same system as in Nottinghamshire. Referring to Plate XI., which is the surface plan of one of the collieries of the district, it will be seen that there are three lines of wagons which can be loaded from four lines of tubs. These tubs pass along, and the hard and soft qualities are picked out separately for steam and house purposes, while the remainder of the coal, called tub bottoms, together with what little slack is drawn out of the pit, is taken away to the screens. These screens being at a higher level, it is necessary to have a steam hoist or an inclined gangway working with an endless chain, or some other such device for raising the tubs to the right height. The tub bottoms are generally divided into cobbles, nuts, and small, but in some cases are sold altogether as rough slack. This system, of course, requires a great many hands and a great many tubs on the bank.

The following list, which is a division of the coal at one of the chief collieries, shows what a large number of different kinds of coal are made while working three seams:—

	Average Price. s.	d.
Best Deep Main House Coal...	8	9
Best Deep Cobbles „	8	0
Screened Cobbles „	6	6
Bright's „	6	0
Best Slate „	7	0
Best Two-yard „	7	0
Ell Coal Spires Steam Coal	6	3
Hard Two-yard „	6	3
Steam Coal	5	6
Nuts	5	0
Rough Slack	3	6
Fine Slack	1	9

This mode of selecting the coal by hand is found to suit the market best, and when well organised is not so expensive as it would seem. With the use of a screen for slack and tub bottoms, the cost is about 3½d. per ton, including weighman and bank foreman; the latter personage being very necessary to prevent the different qualities being carelessly mixed.

MODE OF WORKING.

The most usual mode of working is that known as "forewinning." Plate X. gives a sketch of the usual method of laying out the workings at a Warwickshire colliery, and it will be seen that the pit is sunk to some distance below the seam, and a long flat or kip in the line of dip is made across the measures to cut the coal. After the rise coal has been worked, the main incline is driven to the dip boundary or to a considerable distance, sometimes 900 yards. The coal is then opened out and brought back from here in two large stalls, which are sometimes as much as 400 yards wide, but as a rule do not exceed 250 yards. When this district is finished, slant roads are started out and the rope taken down each of them, but the working faces are generally brought back as square as possible, so as to keep the two sides of the stall of equal length. In this way the old goaf roads are left behind, and the coal is gradually brought back to the pit bottom. The great objection to the method, however, is the impossibility of acquiring more coal in future to the dip, as the old drifts through the goaf could not be well maintained, and the risk of underground fires in the goaves would be very great. In the southern part of the coal-field the seams, as stated above, are very close to each other, and in that case it is usual to work two or more seams at a time, as shown in Plate X. At one colliery there are four distinct faces of coal, each 400 yards long, as shown in Fig. 2, Plate XI., and the Two-yard, Rider, Ell Coal, and Slate Coal Seams are worked one in front of the other. The mode of procedure in this case is as follows:—Two main inclines, one intake and the other a return, are driven out to the boundary, say, a distance of 700 or 800 yards, in the lowest of the four seams, and a face on each side is then opened out in each seam. Each of these eight faces may be holed every day, and about 50 or 60 tons of coal may be easily drawn and delivered on the flat A B from each; the tubs are then pushed forward to the end and attached to the incline rope, which takes from 12 to 15 tubs at a time, the inclination being about 1 in 5. It is therefore good work for one engine to do about 400 tons per day up an engine plane of this length. It will be seen that there are headings between the seams, so that, if necessary, the coal from one seam may be drawn along the face of another should a fall occur.

Another mode of working is the ordinary long-wall method, as pursued in Derbyshire, and consists of driving out a pair of headings, the pillar that is left between them not exceeding 12 yards in thickness, which is quite enough to maintain the main roads. Workings are then opened out, with goaf roads every 50 or 60 yards and a cross-gate every 100 yards,

and the coal is delivered to main rolleyway by ginneys, which do not, as a rule, take more than two or three tubs at a time. This method, however, is not found to be so cheap as the former method, on account of the large amount of repairs required in the goaf roads, the roof being, in most cases, very poor. It is, however, the most convenient method of working to the rise where there is any coal left.

VENTILATION.

In the forewinning method the ventilation is very simple. It is taken down the main incline and proceeds along the face of the last seam, returning along the next one, as shown by the arrows in Plate X., until finally the two currents join at the air-crossing and proceed up the return. In this way it will be seen that there is little danger of spontaneous combustion, as the air-ways are continually changing. As the faces proceed very slowly it is only occasionally that they change the flat bottom. When this is done it is moved forward about 20 yards, or even more, at a time, and in the meantime the faces at the roadside have got rather behind-hand and are then worked up quickly. It is sufficient to place double sheets at the entrance to all the faces to force the air round sufficiently. As there is no gas the current of air is generally small, so as not to provoke fires. The ventilation is generally produced by means of a furnace, and as a large portion of small coal is necessarily left underground, this is perhaps the cheapest method. The furnaces are not, as a rule, of good construction, and have no side passages.

HEADING.

The cost of driving headings is exceedingly high, and this it is believed, is chiefly due to the great importance of driving the inclines or hills as they are called, very carefully at first, to save future maintenance. A good portion of coal is always, where possible, left both overhead and underfoot, and shots are never allowed to be fired for fear of disturbing this roof coal. Main dip inclines generally cost about 8s. per yard, level road, 6 feet by 6 feet and short air-ways 4 feet square, 5s. per yard. Where the seam is thin, it is regarded as of main importance to leave coal on the floor to prevent subsequent creeping.

HAULAGE.

The hauling engine is generally placed on the surface, and the rope is taken down the shaft in boxes. This causes the coal to be delivered immediately at the pit bottom. As the speed is often over 12 miles an

hour and the inclination considerable, the duration of the rope is generally very short. At one colliery, the main engine plane is successfully worked with two ropes and two roads, the ropes working together and drawing the coal first up one side and then up the other, which enables a much larger quantity to be drawn. The ropes at the top have to be put underneath and over short pieces of rail, which take out for the purpose, each time as they are coming up or going down.

There are no endless chains underground, and only one instance of a tail rope, which is worked by compressed air.

GETTING COAL.

The division of labour in a stall is generally carried to a very great excess. It is customary for the holers or getters to go down the pit at 4 a.m., and hole a quantity of coal ready for the fillers, who come at 7 a.m. A stall 50 yards long has two contractors, who employ themselves in blowing down, getting, and breaking up the coal, five getters and four fillers; where the stalls are 80 yards long, these numbers are much higher. As soon as the coal has been holed a yard under, the holers move forward and at seven o'clock the getter-down knocks out the sprags, and if necessary puts in a few shots and gets the coal down. The foremost filler then brings his tub along, and two fillers fill at once by hand, the slack (with the exception of that of the Seven-feet Seam) being thrown back in the goaf. After the day's work is done, the timbermen and repairers come down, make up the packs, move the timber, and generally set the place in order for the next day. The consequence of this is that while nothing works better when all the men attend their work regularly, yet if a single getter is away, the output of the stall is seriously diminished, as the fillers are, as a rule, inexperienced in holing, and are consequently thrown idle before the end of the day. Payment is by the ton, the two contractors taking the risk; the price for small averages about one-third of the price for large. This price includes timbering, packing, and all repairs of every kind except ripping the goaf road.

WAGES.

The wages in this district are distinctly very low, and it has been an arrangement between the masters and men that getters, fillers, and daymen working at a colliery shall be paid according to the standard price. This arrangement is, however, only strictly kept to in the case of the getters. The contractors alone, and those colliers who undertake head-

ings, have the power of making extra wages. The holers have a certain stint work, generally about 5 to 6 yards long and 1 yard deep, for a day, and can of course work extra if they wish.

The banksmen are also paid at a very low rate, and the enginemen and fitters are very much lower than in the North of England. The hours underground are from seven till four, with forty minutes for dinner in the middle of the day, but the men have a very bad privilege of going down the pit and to their work in the masters' time, and returning in their own, after four o'clock. The getters go down at four o'clock, and generally have the opportunity of coming up at half-past eleven during dinner-time. The banksmen work the same hours, but the mechanics work ten hours.

The following list of wages may be interesting:—

	Hours.	s.	d.	s.	d.
Winding enginemen	12	4	9		
Hauling "	12	3	10		
Stokers	12	3	0		
Banksmen	9	2	9	2	7½
Getters	8	3	6		
Fillers	9	3	6	3	2
Repairers	9	3	8	3	6
Day-men	9	3	6	3	0
Onsetters	9	3	10		
Carpenters	10	4	2	4	0
Blacksmiths	10	4	6	4	0
Strikers	10	3	4		
Tub repairers	10	2	9		
Labourers on surface	10	2	9		

This is the standard wage on which at the present time there is an advance of 5 per cent., given in 1882.

GENERAL.

Warwickshire is fortunate in being placed at the lowest railway rate to London, viz., 6s. 4d. per ton, and this is 1s. less than Staffordshire and Shropshire, and 2s. less than Yorkshire and Lancashire. The quality of the coals, however, makes them unsuitable for the London house trade, as they are very smoky, dull in appearance, and unfortunately possess a white ash. They, however, burn very freely and well, and most seams produce a very excellent and hard steam coal, the best portions of which are much liked for locomotive purposes. It is quite useless as a gas coal, as although it appears to contain a fair proportion of gas and bituminous

matter, yet it is entirely devoid of the property of caking. The price, however, is exceedingly low, and the list of prices attached to the different qualities of coal above give a fair estimate of the average price obtained by a Warwickshire colliery during the year.

At most collieries there is a sick and accident club, to which all subscribe threepence per week. This, however, does not admit of the men's families being attended, and they are not able to save enough to be able to erect suitable club buildings, as is so often done in other districts.

To illustrate Mr. E. F. Melly's paper "Notes on the Warwickshire Coalfield."

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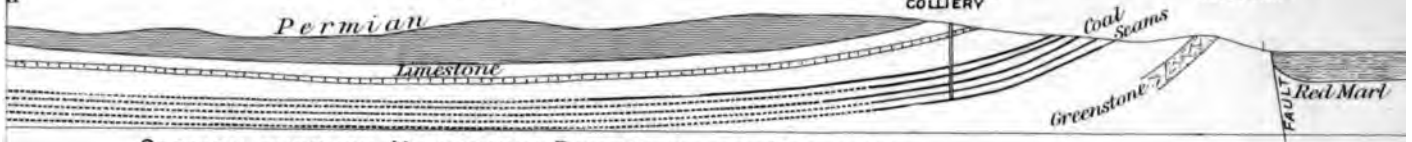
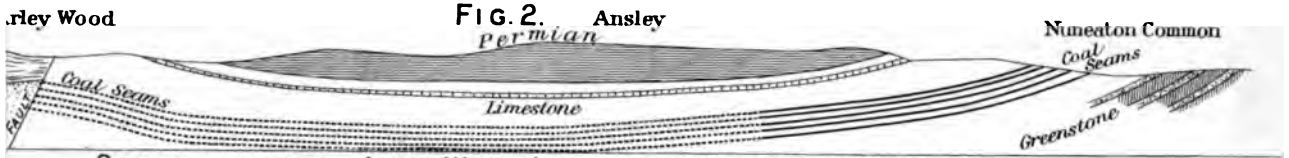
FIG. 1.



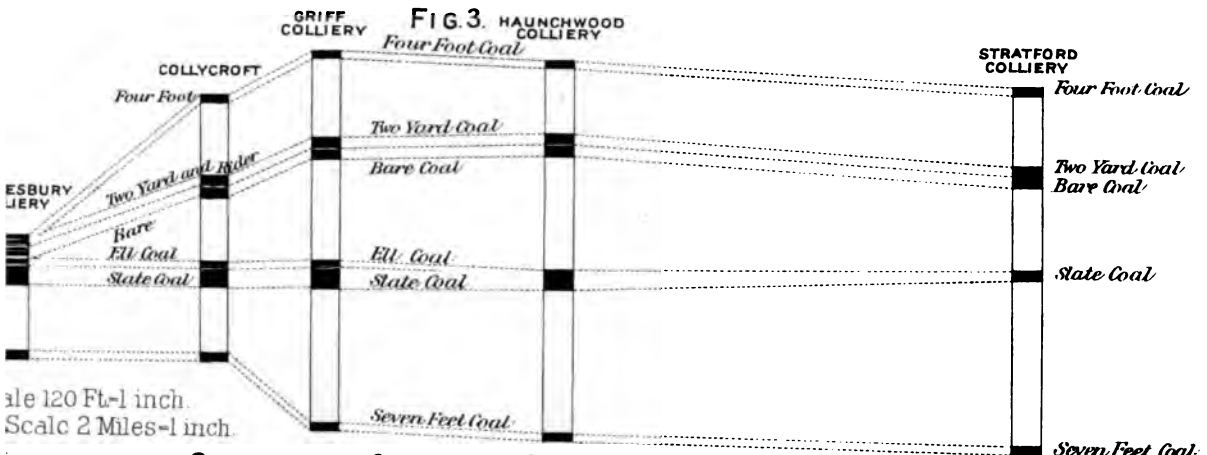
SECTION THROUGH KINGSBURY BAXTERLY AND MEREVALE.

FIG. 2.



SECTION THROUGH ARLEY WOOD ANSLEY AND NUNEATON COMMON.

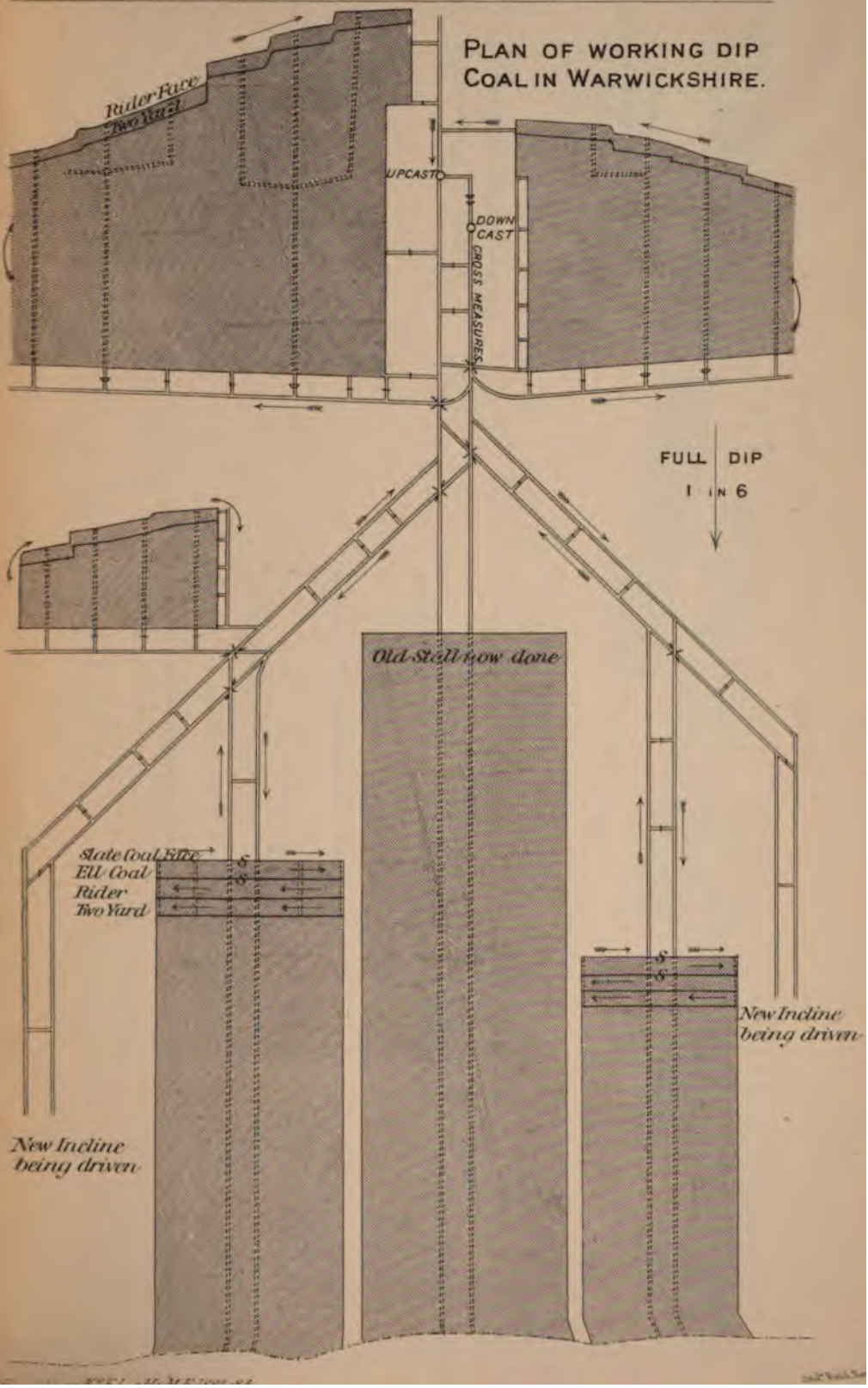
FIG. 3.



COMPARATIVE SECTION OF SEAMS AT DIFFERENT PITS.

Ant. Reid, Newcastle.

To illustrate Mr E. F. Melly's paper "Notes on the Warwickshire Coalfield."



To illustrate Mr. E. F. Melby's paper "Notes on the Warwickshire Coalfield."

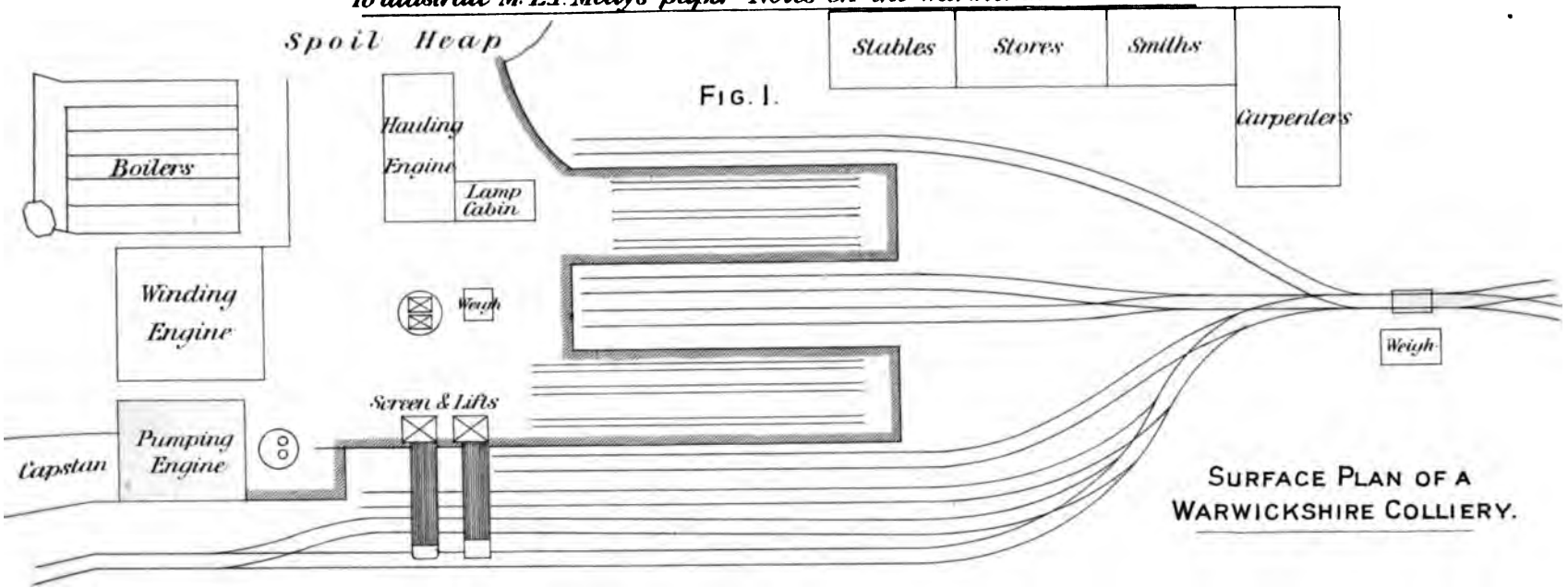
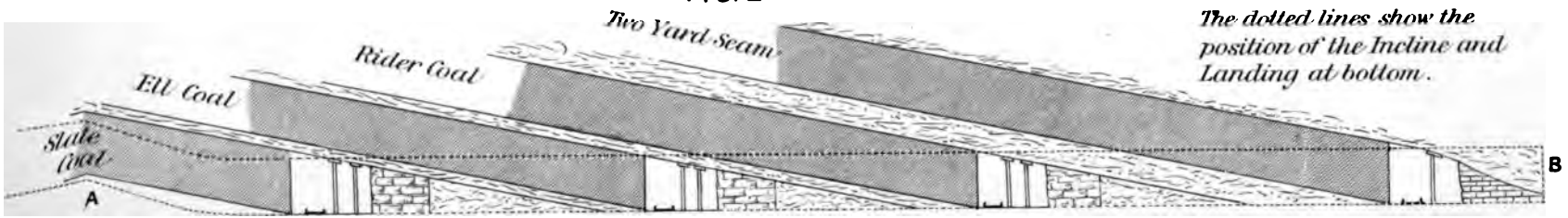


FIG. 1.

SURFACE PLAN OF A WARWICKSHIRE COLLIERY.

FIG. 2



SECTION THROUGH FOUR SEAMS.

Anst. Reid, Newcastle

PROCEEDINGS.

GENERAL MEETING, SATURDAY, JUNE 14TH, 1884, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

GEORGE BAKER FORSTER, ESQ., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting and reported the proceedings of the Council.

The balloting list for the annual election of officers in August was submitted to the meeting in accordance with Rule 21.

The following gentleman was elected, having been previously nominated.

ASSOCIATE MEMBER—

Mr. THOMAS PREST, Pease's West Collieries, by Darlington.

The following gentlemen were nominated for election :—

ASSOCIATE MEMBERS—

Mr. EDWARD ROBERT FISHER, M.E., Cleveland Terrace, Walters Road, Swansea.

Mr. T. SHIPLEY, M.E., New Copley Colliery, Cockfield.

STUDENT—

Mr. GEORGE EDWIN JAMES MCMURTRIE, Towneley Collieries, Ryton-on-Tyne.

Professor LEBOUR read the following paper "On the Breccia-gashes of the Durham Coast and some recent Earth-shakes at Sunderland."

ON THE BRECCIA-GASHES OF THE DURHAM COAST AND SOME RECENT EARTH-SHAKES AT SUNDERLAND.

By G. A. LEBOUR, M.A., F.G.S.,

Professor of Geology in the Durham College of Science, Newcastle-upon-Tyne.

I.

The town of Sunderland is built upon the Permian Magnesian Limestone. The latter (with its subordinate marl-slate) rests, the very irregular and sometimes absent yellow sands of the Permian alone intervening, upon a denuded surface of Coal-Measures. The total thickness of the Magnesian Limestone at its maximum may be estimated as being not much over 600 feet, but at Sunderland the uppermost portion of the deposit is absent. The amount of that rock present there is between 300 and 400 feet. There is very little southerly dip in the limestone, but there is some, and the best way to ascertain the nature of those portions which underlie the town is therefore to study the beds as they crop out in the beautiful cliff sections to the north, between the Wear and the Tyne. These rocks are so strange in structure, and so striking by reason of the variety of their forms, that they have been described in many valuable papers, by the late Professor Sedgwick, Mr. R. Howse, Mr. J. W. Kirkby, and others.* It is not intended in the present paper to repeat what has been so well and so often said before, but simply to draw special attention to one of the strangest and most striking of the developments of the Magnesian Limestone as displayed in Marsden Bay.

There, between the north end of the bay and the little inn in the cliff at its southern extremity, no fewer than fifteen masses of breccia are most clearly shown in the lofty cliff-section.

Now, a breccia is a rock composed of angular fragments more or less firmly cemented together. Just as in a gravel or conglomerate, the rounded pebbles prove them to have come from a distance and to have

* References to several of these publications will be found in the notes in the course of this paper.

been exposed to water-wear, so in a breccia the sharp edges and rough fracture-faces of the enclosed stones show that they lie at or very near the place where they were broken up, or else that they have been preserved from attrition by special conditions, as, for instance, by means of ice or lava.

In the present case neither ice nor lava need, or can be, brought in as having helped to form the breccia. The fragments are, in fact, of the same material as the solid rock forming the mass of the cliff—Magnesian Limestone. Moreover, the cementing matter which binds the fragments together—and binds them so closely that it is sometimes easier to break the enclosed stones than the cement that holds them—is Magnesian Limestone too. But yet there is a difference. For whereas the broken bits of rock have all the varying character of structure and texture of the neighbouring beds from which they have clearly been detached, the matrix in which they lie is more or less amorphous. These breccias are exposed on the cliff-face between walls of ordinarily bedded Magnesian Limestone, and present the following peculiarities:—Sometimes they fill a mere fissure, a few feet at most in width; sometimes a broad one many yards across. Sometimes a breccia-filled fissure is nearly of equal breadth from top to bottom of the cliff; sometimes its upper termination (which is almost invariably broad) and sometimes its lower extremity (which is almost invariably narrow) is exposed in the cliff; sometimes—though more rarely—both top and bottom are shown. In some cases the broken fragments within the fissures can be traced graduating through semi-brecciated portions of beds to wholly undisturbed strata in the walls or fissure-cheeks. When the top of a fissure is exposed in section the breccia is also seen usually to pass gradually upwards, first into semi-brecciated matter, and finally to undisturbed or only slightly synclinal beds bridging over the mass of broken rock. Where the entire transverse section of a fissure is exposed it is seen to be a deep V-shaped ravine or gullet, tapering to a point below, and the rocks below it are wholly undisturbed. Such a case is well shown very near the inn in the cliff.

The varieties of breccia-gashes* enumerated above are illustrated by diagrammatic sketches in Plate XII., Figs. 1, 2, 3, and 4, whilst the nature of the breccia itself is shown in Plate XIII., which has been drawn from a photograph of one of the largest gashes near the north end of Marsden Bay, kindly taken for the writer by Mr. W. G. Laws, jun., A.Sc.

* The word *gash* is a convenient one used occasionally by lead-miners to express a fissure unaccompanied by dislocation. See N. Winch's "Geology of Northumberland and Durham," Trans. Geol. Soc., Vol. IV., p. 30, (1816).

To illustrate Prof. Lebour's paper "On the Breccia Gashes of Durham."

Fig. 1.

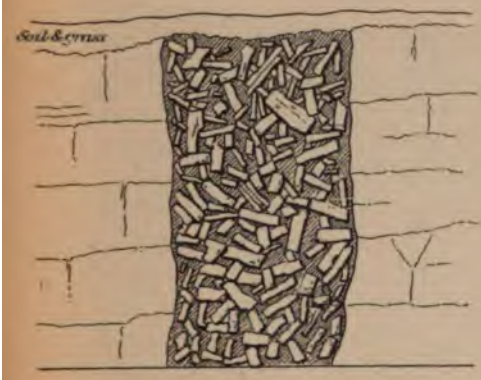


Diagram of Breccia Gash in Cliff with top denuded off and Bottom concealed by the beach.

Fig. 2.

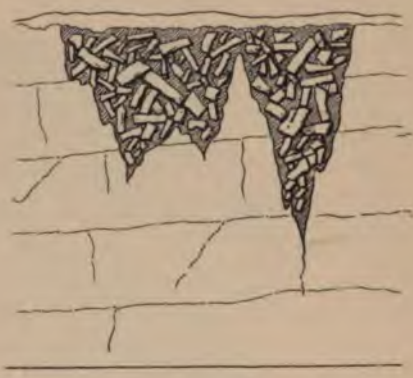


Diagram of Breccia Gashes with top denuded off but bottom shown in cliff.

Fig. 3.

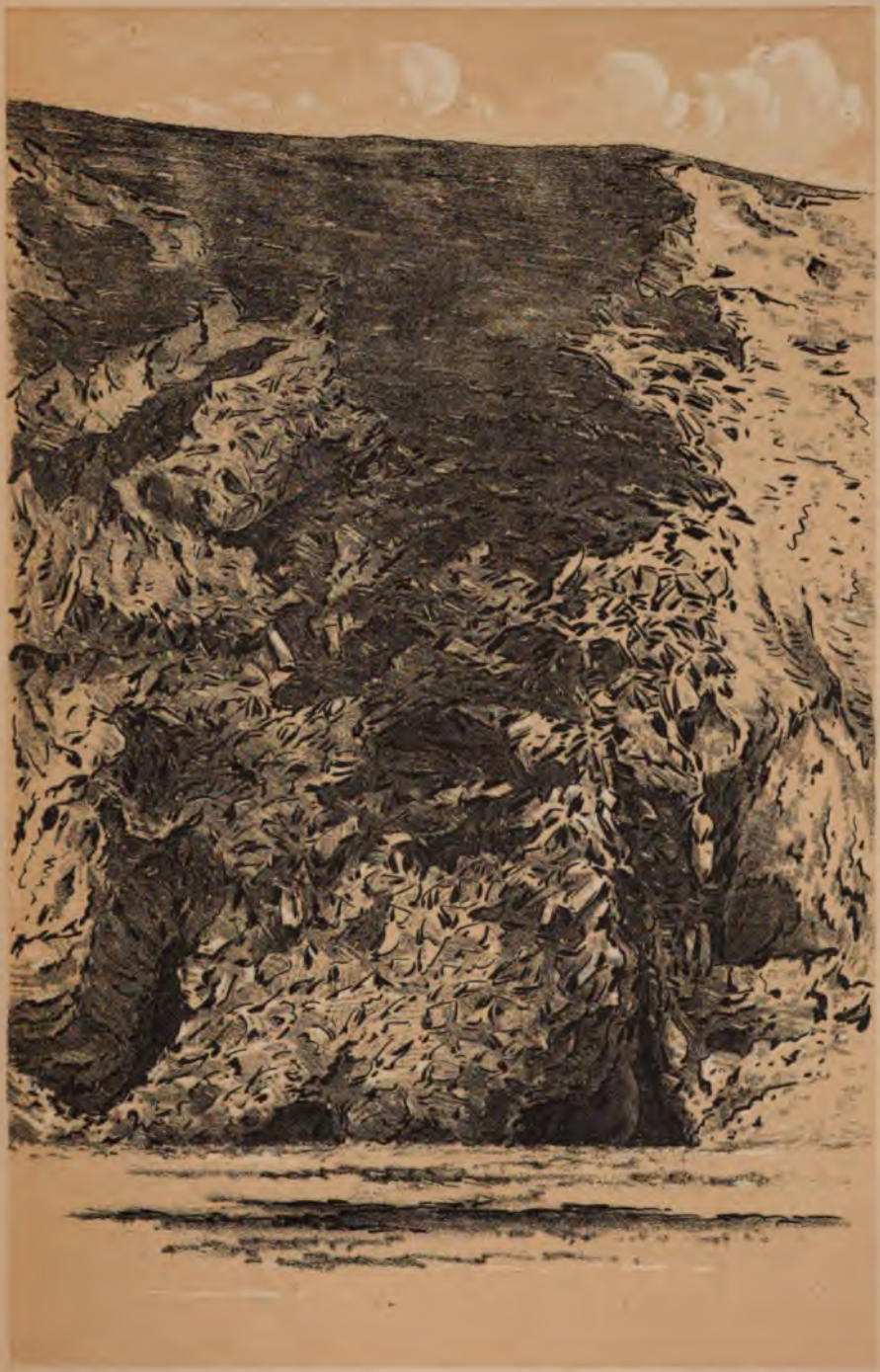
Diagram of narrow Breccia Gashes.

Fig. 4.

Diagram of Breccia Gash showing process of formation.

N.B. In the above sketches the Cementing matter is represented by diagonal shading.

To illustrate Prof. Lebour's paper "On the Breccia Gashes of Durham".



The fragments constituting the breccia are of all shapes and sizes, from blocks a yard or more in diameter to the smallest grains, but all are angular.

II.

Since the beginning of last December (1883) it is well known to most members of the Institute that earth disturbances, which it is not easy to name more definitely, have repeatedly alarmed the inhabitants of certain localities in and near Sunderland. These disturbances have, it is true, been repeatedly called "earthquakes" and "shocks" in the local papers, and it must be admitted that some shaking of the surface and shocks to the dwellers in the affected areas did undoubtedly form part of the manifestations. But the evidences of deep-seated action, and of wide-spread effects due to it, which are characteristic of true earthquakes, have been remarkably absent in all published and unpublished records of the occurrences. Indeed, the disturbances have been singularly local—limited almost entirely to the Tunstall Road neighbourhood of Sunderland, and, it would appear, to certain linear directions within that district. For some months the writer has been kept informed of the successive "shocks" through the kindness of several gentlemen, among whom Professor G. S. Brady, F.R.S., Mr. J. B. Atkinson, Mr. W. S. Harrison, B.A., A.Sc., Mr. C. L. Cummings, and Mr. G. Shaw must be specially mentioned. The results of the information thus gathered from various and independent quarters are briefly as follows:—

That in the district mentioned above, sudden shakes of houses accompanied with rattling of crockery and windows and in one case the upsetting and breaking of a globe off a chandelier, cracks in the walls, and heaves of the floor have been felt over and over again during the past five months. That loud noises and dull rumbles often, but not always, were heard following the shakes. Lastly, that though in most cases there has been no difficulty in getting plenty of corroborative evidence as to the character, time of occurrence, and duration of the more severe shakes, many persons residing within quite a short distance from the line of greatest force have felt or noticed nothing.

Mr. Chas. L. Cummings, who is, unfortunately for himself and his house, evidently most favourably situated for the observation of the phenomena in question, and who has from the beginning most carefully noted all their details, has published the subjoined table which gives a better idea of the nature of the disturbances than is otherwise obtainable:—

TABLE SHOWING SOME OF THE SHOCKS FELT IN THE LOCALITY OF TUNSTALL ROAD, SUNDERLAND.

Month and Date.	Day.	Time.	Effects.
1883.			
Dec. 7	Friday ...	2 8 p.m.	Sudden and terrific thud, as if from blasting operations.
„ 7	„ ...	2 22 „	Severe shake, accompanied with rumbling noise.
„ 18	Tuesday ...	1 15 a.m.	Very sharp shock, shaking house; not so severe as on the 7th inst.
„ 19	Wednesday..	8 30 „	Slight shock.
„ 20	Thursday ...	8 30 „	Sudden, sharp shock.
„ 20	„ ...	11 15 „	Very sharp shock.
„ 21	Friday ...	4 32 p.m.	Slight shock, accompanied by rumbling noise.
1884.			
Jan. 10	Thursday ...	7 20 „	Slight shock.
„ 12	Saturday ...	8 14 a.m.	Very sharp, severe shock; proper shake of house.
„ 22	Tuesday ...	4 55 „	Awoke by sudden rattling of jugs in wash-basin.
„ 29	„ ...	9 7 p.m.	Slight shock.
Feb. 10	Sunday ...	11 7 „	Severe, startling shocks.
„ 14	Thursday ...	7 17 a.m.	Sudden rattling of bedroom ware.
Mar. 2	Sunday ...	4 20 „	Awoke by alarming shake of house; thought the walls were giving way.
„ 2	„ ...	10 0 „	Slight shock.
„ 6	Thursday ...	5 56 „	Sudden, sharp shock.
„ 6	„ ...	8 10 „	Severe shock.
„ 7	Friday ...	8 30 „	House shook.
„ 11	Tuesday ...	4 33 „	Awoke by awful shaking of bed and furnishings.
„ 12	Wednesday..	2 50 „	Severe shock.
„ 13	Thursday ...	6 56 „	Slight shock.
„ 16	Sunday ...	7 25 „	Sharp, severe shock.
„ 18	Tuesday ...	9 24 „	Sharp, severe shock.
„ 18	„ ...	4 4 p.m.	Severe shock.
„ 19	Wednesday..	10 55 a.m.	Frightful shake; almost as bad as that of Dec. 7.
„ 20	Thursday ...	6 11 „	Slight shock.
„ 26	Wednesday..	7 9 „	Do.
„ 26	„ ...	7 11 „	Do.
„ 27	Thursday ...	7 37 „	Do.
„ 27	„ ...	11 7 p.m.	Very severe shock, shaking house.
„ 29	Saturday ...	2 12 „	Slight shock.
April 2	Wednesday..	4 27 a.m.	Awoke by frightful shock, causing complete oscillation of whole house.
„ 2	„ ...	3 33 p.m.	Severe shock.
„ 3	Thursday ...	2 45 a.m.	Slight shock.
„ 4	Friday ...	8 35 „	Do.
„ 5	Saturday ...	10 45 „	Awfully severe shock; house shook, windows rattled.
„ 7	Monday ..	7 19 p.m.	Slight shock.

Since the last date given in the above table the phenomena have continued much in the same manner, without either sensibly increasing or decreasing in intensity. For the purposes of this paper the above facts, confirmed as they are by numerous independent witnesses, are amply sufficient. It will only be necessary to add that Mr. W. S. Harrison informs the writer that a lady who heard the rumbles attending the first notable shock on December 7th states that "it closely resembled a

similar one which occurred sixteen years ago, and which caused a subsidence of land on Tunstall Hill."* This, as will presently appear, would, if properly substantiated, help to prove a very important point.

III.

The stage which the present paper has now reached is briefly this, viz.:—Certain peculiarities common in a portion of the Magnesian Limestone which underlies Sunderland have been described, and certain recent noises and tremors of the ground affecting parts of that town have also been called attention to. It now remains to show that there is a possible or probable connexion between these two subjects.

In the first place it is clear that ever since the Permian calcareous Breccia-gashes of Durham were first noticed by geologists they have, with very few exceptions, proved a puzzle to all. Winch, writing in 1814, says, with reference to them:—" · · · and with this breccia wide chasms or interruptions in the cliff are filled."† He attempts no explanation of either chasms or breccia.

Sedgwick, in his classical paper on the Magnesian Limestone, published in 1835, although he describes the breccia itself fully enough, scarcely does justice to its singular mode of occurrence in Marsden Bay. All he can say as to its origin is this:—" It appears then, that these breccias are neither at the bottom nor at the top of the formation of Magnesian Limestone, but that they are subordinate to it; that the disturbing forces which produced them were violent, mechanical, and local, and in some instances were several times brought into action; and that they were not of long duration; for the fragments of the beds are not water-worn, and appear to have been re-cemented on the spot where they were formed."‡ This is highly suggestive and, so far as it goes, strictly accurate, but no hint is given as to what " the disturbing forces which produced" the brecciated rock might be.

Sir Charles Lyell, in a letter to Leonard Horner, dated September 1st, 1838, thus refers to the coast at Marsden which he had just visited for the first time:—" The coast scenery was very grand, and the brecciated

* There is also some less definite evidence of shocks of much the same character having taken place in or near Sunderland about eleven years ago. Information as to any occurrences of this kind prior to 1883 would be very thankfully received by the writer.

† " Geology of Northumberland and Durham," Trans. Geol. Soc., Vol. IV., p. 6, (1816).

‡ " On the Geological Relations and Internal Structure of the Magnesian Limestone," Trans. Geol. Soc., Series 2, Vol. III., p. 92 (1835).

form of the Magnesian Limestone, which is an aggregate of angular masses of itself, as if broken up and reconsolidated *in situ*."*

At a later date, in his "Elements of Geology," Lyell recurred to the subject in greater detail, but came to no conclusion. He writes:—"· · · but the subject is very obscure, and studying the phenomenon in the Marston [*i.e.*, Marsden] rocks, on the coast of Durham, I found it impossible to form any positive opinion on the subject."†

In 1863, in their useful "Synopsis," Messrs. Howse and Kirkby were the first to offer an explanation of the breccias in question. After mentioning the chief dislocations of the district they add:—"But besides the faults above mentioned, there are of course numerous minor breaks affecting the limestone, some of which possess considerable geological interest. Sometimes these latter take the form of rubble or breccia dykes, the space between the walls of the fissure being filled irregularly with large and small angular blocks of limestone, cemented together with a calcareous paste. Remarkable examples of these occur on the coast between the Tyne and the Wear, one of the best being the "Chimney" just to the south of Marsden grotto. The remarkable appearances presented by these breccias at Marsden may, we think, be explained by the filling up of large fissures and chasms with broken fragments of the superincumbent strata, and may perhaps be safely attributed to earthquake action on these rocks at an early period."‡

The late Professor David Page, who had spent some years of early life at Sunderland, and therefore knew the coast details well, more than once in conversation with the writer expressed his acceptance of the earthquake theory as accounting for the Breccia-gashes.

So much, then, at present, as regards the attempts which have, so far, been made to clear up their origin. Many more suggestions have been made respecting that of the Sunderland earth-shocks.

Very naturally, in the first moment of local excitement, the thoughts of many were turned towards the collieries, many of which it was well known extend widely in the Coal-Measures beneath the Permian rocks. It was hinted that the shocks might have been caused by shot-firing or

* "Life, Letters, and Journals of Sir Charles Lyell, Bart." Vol. II., p. 42 (1831).

† 6th edition (1865), p. 475. The passage appears as given both in earlier and in later editions.

‡ R. Howse and J. W. Kirkby, "A Synopsis of the Geology of Durham and part of Northumberland," p. 18 (1863). The term *dyke* is very descriptive, but as, geologically speaking, it is almost invariably associated with intrusion from below, it has been thought better not to apply it to fissures which, whatever their origin, were certainly filled from above.

by falls of stone in neighbouring pits. As the Monkwearmouth Colliery was the nearest, the manager of that colliery, Mr. Parrington, replied to the inquiries which were made on the subject in the daily papers, by explaining that his workings did not underlie the area affected by the shock, and that there was no blasting going on in them. This answer, coupled with the great depth of the colliery in question, satisfactorily settled the underground shot-firing theory; but in his letter Mr. Parrington suggested another to take its place, and attributed the occurrences to the existence of natural water-blasts in the body of the Magnesian Limestone. Others, also well acquainted with that rock, have adopted that view.

Then blasting operations in quarries were proposed as likely causes, but many good reasons (*e.g.* the quarries not being worked at the time, many of the shocks being felt during non-working hours on week-days, also several times on Sundays, etc.), soon repelled that accusation.

That the shocks were true earthquake shocks was sufficiently disproved by their extreme localization, and the clear indication which they give of an action the reverse of deep seated.

Lastly, the withdrawal of water previously filling up, and therefore also to a certain extent helping to sustain, the walls and ceilings of cavities within the limestone, and the consequent falling in of such walls, have been pointed to (though not, to the writer's knowledge, in print) as capable of producing the effects observed. This possible explanation has not been in any way disproved, and deserves careful consideration.

That the Magnesian Limestone is riddled with cavities of every size and shape is locally matter of common knowledge. Nor can it be said that the origin of many of these cavities is difficult to trace. In some cases the smaller of them are due to the original "vuggy" or cellular character of the stone—a character which is intimately related to its eminently water-holding qualities. But the larger cavities are often true caverns formed by the double action of mechanical and chemical agencies, and that these agencies are still at work in the manufacture of such caverns there is abundant evidence to show. How readily the Magnesian Limestone is acted on by mechanical agents of denudation and waste is shown by the numerous caves along the shore. All these combine the typical characters of sea-caves as enumerated by Professor W. Boyd Dawkins, F.R.S., viz., they have flat or scarcely sloping floors, and are usually widest below. They seldom penetrate far into the cliff, and their entrances are in the same horizontal plane (that of the beach at high-water line, whether that beach be the present one, or an ancient one or

raised beach).* Such caves are evidently to a much greater degree the work of the moving shingle and sand than of the acid-water to which they nevertheless in some slight degree also owe their production. But these sea-margin caverns are insignificant when compared with the countless gullies, gashes, and holes of every description which cut the internal body of the limestone through and through. The history of the latter is different. Many of them may be accounted for by noting how frequently masses both large and small and of the most irregular forms of soft pulverulent earthy matter occur in the midst of the hardest and most compact portions of the limestone. An afternoon's walk along the face of the South Shields quarries, between that town and Marsden Bay, will render this sudden utter change of texture in the stone patent to any one. How easily such soft and incoherent material can be removed by the merest percolation of rain-water needs no proof, and that caverns would result and have resulted from such removal is also clear. This action is indeed chiefly mechanical, but there is also going on at the same time in the limestone a continual destruction of its substance as rock by the purely chemical ordinary action of rain-water on limestone. How great this action really is may perhaps be best understood when it is stated that in every thousand gallons of Sunderland water there is nearly one pound of lime and magnesia; or, in other words, every thousand gallons of that water pumped up represents a pound weight of rock abstracted.† In the course of a year the amount of hard compact Magnesian Limestone carried away by the Water Company's works would not fall much short of forty cubic yards. If to this be added the amount of water similarly charged with lime and magnesia, which runs off to the sea from springs, streams, and rivers, the enormous amount of stone annually lost by the Permian series in East Durham can be better imagined than represented by figures. A cubic foot of Magnesian Limestone of the less crystalline varieties when saturated holds from 3·45 lbs. to 17 lbs. of water; the crystalline forms hold very little.‡ This bears out the statement made twenty years ago in these Transactions by Messrs. Daglish and Forster, and confirmed by all subsequent experience, that the feeders of water met with in sinking through the Magnesian

* See "Cave Hunting," p. 24 (1874).

† The quantity of water delivered by the Sunderland and South Shields Water Company, and pumped from an area of fifty square miles of Permian rock, was 4,500,000 gallons per day in 1879. 100,000 lbs. of Sunderland water contained (according to the Rivers Pollution Commissioners) 5·89 lbs. of lime and 3·96 lbs. of magnesia. *See* De Rance, "Water Supply of England and Wales," pp. 56–59 (1882).

‡ De Rance, *id.*, p. 59.

Limestone "are derived not so much by percolation through the mass of the rock—for this can obtain to a small extent only—but collected in and coming off the numerous gullets and fissures which everywhere intersect and divide the mass of the strata."* These gullets are often very large, such, for instance, as that met with in sinking the Whitburn Colliery shaft in 1874, from which 11,612 gallons of water were pumped per minute for a month at a time,† to say nothing of the many other recorded cases of the kind at Murton and elsewhere; and the considerations above brought forward go to show that they are even now constantly increasing in size, and new gullets are as constantly coming into existence.

Here then are the conditions to which it is desired that attention should be directed:—A mass of stone, mostly hard and compact, but cellular in places and earthy and friable in others; often cavernous on a large scale; full of water, and through its action continually parting with its substance, and thus enlarging the cavities within it.

By the mere force of gravity the vaults of the cavities last mentioned must from time to time give way, and when that is the case the cavity will become filled with the *débris* of the superincumbent rock. These *débris* will be angular; they will lie where they fell, and if circumstances be favourable to such a deposit (and on a cliff coast-line above the saturation level of the limestone they are eminently favourable), may easily in time be cemented together by the very material which the water has abstracted from the rock in the first instance, and in such cases returns to it, just as in other limestone districts waters which have hollowed out caves often partly fill them once more with stalactitic matter.

Such falls of gullet-vaults will occur in time even when the cavities are full of water. If, however, the water which they contain be removed either by natural or by artificial means the falls will be much accelerated. In whatever way they have been caused such smashes of solid rock must produce violent concussions accompanied by noise, but limited in the area over which their effects would be felt. In short, it appears to the writer that to accept such natural stone-falls at moderate depths as an explanation of the Sunderland earth-shocks is to accept a theory consistent with every one of the facts of the case.

* J. Daglish and G. B. Forster "On the Magnesian Limestone of Durham," Trans. North Engl. Inst. Min. Eng., Vol. XIII., p. 205 (1863-64).

† J. Daglish "On the Sinking of Two Shafts at Marsden, for the Whitburn Coal Company," Proc. Inst. C.E., Vol. LXXI., p. 180 (1882). The above amount of water included, it is but fair to add, a considerable amount of salt water coming probably directly from the sea.

But the theory goes further than this, and explains equally well, the writer thinks, all the facts connected with the puzzling Breccia-gashes of the coast. The forms of these gashes, which are gullet-shaped and tapering downwards, unlike the sea-caves; the breccia with which they are filled; the matter with which the fragments are cemented; the half-broken beds which so often bridge over the upper portions of the fissures; and the unbroken beds immediately above and below them, which would be inconceivable had the fissures and their in-fillings been due to real earthquakes—all these things are necessary accompaniments of the rock-collapses which, it has been shown, must in time past have happened frequently, are happening still, and must happen more and more frequently in the future.

Mr. C. L. Cummings said, that all he knew upon the subject was contained in the paper. These shocks had not been felt so often since the time referred to. For about a week the shocks occurred almost always at midnight, and at no other time.

Mr. R. Forster asked whether, with the head of water lowered, and the quantity of stone carried away seaward by the more rapid flow of water, these Breccia-gashes would not be more likely to increase?

Professor Merivale did not see why these gashes should be pointed at the bottom. He would like to have this more thoroughly explained.

Mr. John Daglish said, in sinking through the limestone at Marsden they had met with large fissures. One of these, met with in the pit was bored through under water, and, therefore, they never saw the fissure; but it was more than 12 feet wide. At one time in going through that part of the pit the trepan did not touch the rock more than 6 inches on one side, the rest was a cavity; and when they came to fill in with cement behind the tubbing a great amount of material was required. He would be glad to put in the figures when the paper was discussed. This was not a cavern, it was evidently a large fissure. He presumed Professor Lebour suggested that these Breccia-gashes originally had been in that form, and that the surrounding rocks had fallen in.

Mr. Parrington said, he was sorry that none of the officials of the Sunderland Water Company were present, as he would have liked to have known what was the variation in the level of the water between the

starting of the pumps in the morning and the leaving off at night at Humbledon Hill; for instance, which was the pumping station nearest to where the shocks occurred. Professor Lebour had mentioned that he (Mr. Parrington) had a theory that these shocks were due to water-blasts in the gullets, such as Mr. Daglish mentioned.* He (Mr. Parrington) thought this was rather a reasonable theory. He had had a conversation on the subject a short time ago with Professor Warington Smyth, who made an apt remark—that if air pent up in small water-pipes could make the noises and shocks they knew it did, how much more would it do so in large spaces like these fissures. In the neighbourhood where Mr. Cummings, unfortunately for himself, lived, there was something like 60 fathoms of limestone; the head of the water was about 20 fathoms below the surface, and there was, therefore, about 40 fathoms of water. He had information—and he would have liked to have asked the Sunderland Water Company's officials if it was correct—that the level of the water varied 14 fathoms between night and morning. If this was the case he thought it reasonable to suppose that, the water rising 14 fathoms in a chain of gullets which probably existed in that district, and the air escaping after being pent up to a high pressure at the top of these gullets, would have the effect which, unfortunately, causes annoyance to the residents in the neighbourhood.

The PRESIDENT asked Mr. Parrington if he thought that the water-blasts took place through the alteration in the level each twenty-four hours?

Mr. PARRINGTON said, he was informed that the Company begins pumping in the morning, lowering the water 12 to 14 fathoms during the day, after which the water rises.

The PRESIDENT—The water-blast is generally supposed to be formed by the gases gathered in the course of time, but not in one day's work.

Mr. PARRINGTON—If, however, the water rises so rapidly in these gullets, the pent up air will rush out of the lower ones as rapidly. A head of very few feet in the pit causes the air to make a tremendous noise in rushing out.

Mr. R. FORSTER said, he could not give any data as to the rise and fall at the Sunderland Water Company's pumping station; but, having an

**Extract from Paper "On the Sinking of two Shafts at Marsden." By John Daglish, Trans. Instit. Civil Engineers, 1883, Vol. LXXI., p. 188:*—"A large gullet was passed through in No. 2 Pit at a depth of 56 yards from the surface, the width of which was nearly the whole diameter of the Shaft. When concreting at this point, 120 cubic yards of small stones and concrete were filled in, and 80 and 40 cubic yards at smaller gullets lower down (Plate 4, Fig. 8,) without sensibly raising the level of the concrete."

idea that the pumping was affecting the general level of the water under the limestone, he had had a record kept for the past four years, registering every twenty-four hours the ebb and flow, or the rise and fall of the water; and he would supply the Institute with a copy of the diagram.

Mr. PARRINGTON said that, with respect to these Breccia-gashes, which were really of more interest than the earth-shakes to the members of this Institute, he mentioned to Professor Lebour one thing which was very interesting, and that was the disappearance of small streams in the limestone in summer time. He specified one stream in particular—not a very small one—between Fulwell and Monkwearmouth, which ran through Monkwearmouth cemetery, and disappeared at certain times into the limestone, sometimes to rise again within a mile, while the spring from which the stream rose never seemed to fail.

Mr. DAGLISH—The same thing takes place at Castle Eden and the dene north of Seaham. The water disappears altogether.

The PRESIDENT—It is a very common thing in the mountain limestone.

Mr. MARKHAM—Will Professor Lebour tell us the reason why he thinks these earth-shakes will occur more frequently in the future than in the past?

Professor LEBOUR said, the first question asked was whether he did not think that the water being lowered would make such falls more likely? Most undoubtedly it would; and this was one of the arguments in his paper. The water, of course, helped to support the walls where it filled these gullets, and when the water was withdrawn, so much support was also withdrawn from the walls, and they were more apt to collapse. If any one could give any clear and distinct information that such a tremendous rise and fall of water, as mentioned by Mr. Parrington, took place by the action of the Water Company pumping, that would show excellent cause for the increased occurrence of such falls of stone. The last speaker asked why he (Professor Lebour) thought these falls would happen more frequently in the future. Simply because these gullets were slowly becoming larger and larger daily. It was fortunate that they had Mr. Forster and Mr. Daglish present on this occasion, as they were the authors of, he might say, the best paper on the limestone of Durham which had appeared in the Transactions on this subject. Professor Merivale asked why Breccia-gashes were pointed at the bottom. It was because they were to all intents and purposes water channels. The tendency of water was to fall to a lower level, and to dig a channel deeper and deeper. There was among these gullets a kind of underground river-system, though not

always at the same level—a kind of many storied water-system, flowing one into the other, but all tending to the sea. It would be interesting to get the details as to the great fall of water mentioned by Mr. Parrington. There was no reason, without giving up an inch of his own theory, why he should not adopt Mr. Parrington's. If mining engineers said that the lowering of the level of the water by the Water Company or others pumping was liable to make the water-blasts, he (Professor Lebour) was willing to accept that; and that might account for the great noises heard in connection with the earth-shakes in Sunderland. But this did not in the slightest degree militate against the explanation he had brought forward.

Mr. PARRINGTON said, he saw at page 58 in De Rance's "Water Supply of England and Wales," that no less than 5,000,000 gallons a-day were pumped from the magnesian limestone without in the least altering the permanent level of the water in the district. He (Mr. Parrington) quite agreed that the permanent level of the water at Sunderland was not altered; but he would ask Mr. Forster if towards the outcrop, the level of this water was not permanently lowered?

Mr. R. FORSTER said, he understood that this paper would come up for discussion at a future meeting, and he proposed to answer Mr. Parrington's question by putting in the diagram to which he had already alluded. He wished to ask, however, if the head of water were lowered, would not that have a tendency to cause, in the underground river or lake, the flow of water to be more rapid, and so, taking away the foundation of these Breccia-gashes, cause the falls to be more frequent, and carry off more limestone with it?

The PRESIDENT said, the paper would be discussed at a future meeting. He proposed a vote of thanks to Professor Lebour for the interesting information he had given the members in the paper. This was a subject in which Mr. Daglish and himself took considerable interest twenty years ago; but their experience was now old, and perhaps was superseded by the information of the present time. It was important that information on this subject should be gathered, and embodied in the Transactions of the Institute.

The vote of thanks was agreed to.

Mr. M. WALTON BROWN read the following paper "On the Observation of Earth-shakes or Tremors, in order to foretell the issue of sudden Outbursts of Fire-damp:"—

ON THE OBSERVATION OF EARTH-SHAKES OR TREMORS, IN ORDER TO FORETELL THE ISSUE OF SUDDEN OUTBURSTS OF FIRE-DAMP.

By M. WALTON BROWN.

Whatever may be the cause of the issue of sudden outbursts of fire-damp, the quantity of gas produced is extremely variable and irregular. Many theories have been from time to time advanced with the object of defining the laws which govern these sudden outbursts of gas from coal and adjacent strata.

It would appear that there is some connection between sudden outbursts of gas and the motions to which the crust of the earth is subject: in other words, that slight motions of the earth's crust may be followed by more or less violent outbursts of gas. Thus, if there were a large body of gas pent up in a subterranean reservoir, and some movement of the earth's crust took place forming fissures of varying depth and width, affording channels for the escape of this gas; upon such a fissure being reached in the workings of the mine, a blower would be the result, the volume and duration of which would depend upon the volume of the reservoir, pressure of gas, and the width of the fissure. If this theory is the true solution of the problem, it follows that the systematic and regular observation of earth movements would eventually prove a reliable means, to some extent, of foretelling when outbursts of gas should be anticipated.

This theory, by no means a new one, was first broached in the *Durham Advertiser*, of July 25th, 1845, by the late Mr. William Lloyd Wharton, in describing a curious issue of gas which took place from the bed of the river Wear. The following is an abstract of his remarks:—"A line of streams of gas was observed crossing the river Wear, diagonally in the direction of N.N.E. and S.S.W., under the Framwellgate Bridge, and for a length of about 100 yards. When the air and water were perfectly calm, large bubbles formed by the ascent of gas, taking fire at a lighted candle, marked

the limits of the streams of gas above the bridge, and two other smaller groups of bubbles were seen below the bridge, each of these groups being marked by numerous bubbles. It is believed that there are no coal workings or excavations of any kind within several hundred yards of the Framwellgate Bridge, and the escape of gas must be attributed to some extensive natural accumulation. There is therefore no ordinary means of accounting for this appearance of the gas, but there is no difficulty in conceiving that the escape has been made through some open fissure created by some motion of the earth."

The most violent motions, or earthquakes, are well known to produce fractures, fissures, and chasms, accompanied by subsidence or elevation, forming abrupt heights upon the surface, which may also be rent by fissures or ravines. There are also minor disturbances of the earth's crust, the existence of which is much less obvious than the phenomena of earthquakes, but which are the more general, if less important. These minor disturbances, produced by slow undulatory motions of the earth's crust varying the inclination which the parts relatively bear to each other, must, from the very nature of their action, form open or close fissures which may give vent to sudden blowers of gas, escaping from more or less distant reservoirs, or by a reverse action may stop the issue at a blower in action, or may cause the issue to be intermittent.

From experiments on the amount of disturbance of gravity caused by lunar attraction, made by Messrs. G. and H. Darwin, it appears that the surface of Great Britain is subject to movements of an undulatory and vibratory nature. There are many theories to account for these microseismic motions. Mr. G. Darwin considers that they may be due to the height of the tides and to the pressure of the atmosphere. In fact, if it be assumed that the crust of the earth is plastic, like a hollow ball, it can readily be admitted that the variations of the internal pressure, and of the external pressure or weight placed upon the surface must tend to, and will, produce undulatory and vibratory motions of the earth's crust.

Professor John Milne, of the Imperial College of Engineering, Tokio, thinks that the magnitude of these disturbances is so great that their origin can hardly be attributed solely to these or such like causes, and that they may be more especially produced by the internal phenomena of the earth.

Possible, if not decisive, evidences of the existence of these pulsations have been observed in the soil of Italy, by means of pendulum experiments. Other observations by means of delicate levels appear to show that the relative positions of distant points do vary from time to time.

Assuming that the existence of these phenomena is proved, it can readily be imagined that they are also accompanied with minor forms of the violence found to be associated with earthquakes. These may be described as upheaval, or subsidence, of the earth's crust, formation of fissures, land slips, etc.

Great Britain is, as has been already mentioned, somewhat subject to the phenomena of earthquakes, and more especially to these minor pulsations and tremors, and the East Coast appears to be situated (see Plate XIV.) on a belt subject to these minor pulsations, and connecting the more violent motions experienced in Italy and Iceland, and this the record of observations at Sunderland given in Mr. Lebour's paper might seem to prove ; and the more so, as in the course of the great earthquake at Lisbon, which occurred in November, 1755, there were clear evidences of violent motion, more especially in the water of lakes, etc., in this country; notably, near Durham, where the water in a pond rose and fell about one foot, four or five times per minute for six or seven minutes.

If this theory prove acceptable it affords a plausible reason for the simultaneous occurrence of outbursts of gas along the line of faults, or series of faults or fissures. Consequently, in faulted districts an almost insensible motion of the earth's crust may be accompanied with more or less sudden and violent outbursts of gas, as the least fissure could afford ready issue for the escape of considerable volumes with more or less rapidity.

The tabulation of the occurrence of more than seven thousand earthquakes shows that there is some connection between the pressure of the atmosphere and the occurrence of earth movements. It is said that the observations of earth-tremors and pulsations in Manilla and Japan afford very marked coincidences with atmospheric pressures, and in the case of Manilla they appear in some instances to have formed a perfect indication of approaching typhoons.

If these micro-seismic storms (as these vibratory undulations may be called) are followed by changes of atmospheric pressure, it would appear as exceedingly probable that there is some intimate correlation between them and outbursts of gas.

The following table contains a record of the earthquakes in Great Britain and the Northern Isles, as tabulated by the late M. Perry, of Dijon, and in a parallel column are shown the number of fatal explosions of gas that have occurred in Great Britain from 1868 to 1882 inclusive. The table is arranged to show the monthly occurrence of the two phenomena, and whilst the correlation is by no means perfect, it shows to some

extent that the coincidences are well marked and tend to prove that there may be some connection between the two phenomena. This connection is more clearly shown on the diagram, Plate XV.

MONTHS.	Earthquakes in Great Britain and the Northern Isles.		Fatal Explosions of Gas in Great Britain.		Mean Observations at Greenwich Observatory.	
	Number.	Relative Frequency.	Number.	Relative Frequency.	Barometer.	Thermometer.
January	21	1·16	46	·86	29·729	38·7
February	16	·89	51	·95	29·832	39·7
March	19	1·05	50	·93	29·722	41·5
April	16	·89	59	1·10	29·803	47·5
May	16	·89	53	·98	29·777	53·1
June	10	·55	48	·89	29·828	59·8
July	9	·50	50	·93	29·809	62·6
August	19	1·05	53	·99	29·799	61·9
September	24	1·32	57	1·06	29·787	57·5
October	17	·94	70	1·30	29·720	51·0
November	22	1·22	45	·84	29·771	42·7
December	28	1·54	63	1·17	29·791	40·8
TOTALS	217	12·00	645	12·00	29·780	49·7

In conclusion, it appears desirable that experiments should be initiated in this country for the observation of these micro-seismic motions, to be conducted similarly to those which have been so carefully pursued in Italy and which have been more recently established in Japan. Since January of this year, the Japanese Government have inaugurated a series of experiments to be made at the colliery of Takashima, one of the largest in that country. These underground experiments, which are to be made under the superintendence of Professor John Milne, of the Imperial College of Engineering, Tokio, are for the purpose of ascertaining (as detailed in the *Japan Gazette* of January, 1884) whether there are any phenomena connected with the issue of gas, such, for instance, as earth-tremors, which hold a nearer relation to the evolution of gas than barometrical changes.

As the order of these experiments are such as should be followed in this country, the following details are of value. The experiments now in progress are:—

1.—The observation of earth-tremors by means of a tromometer. This instrument consists of a pendulum protected from currents of air, and a microscope so arranged that the smallest movements of the pendulum in any direction can be readily seen and measured.

To illustrate Mr. M. W. Brown's paper "On the observation of Earth-shakes or Tremors, in order to foretell the issue of sudden outbursts of Fire-damp."

Seismographic Map of Western Europe.

Shewing the Distribution of Earthquakes,

(From the Map prepared by the Messrs. Mallet.)

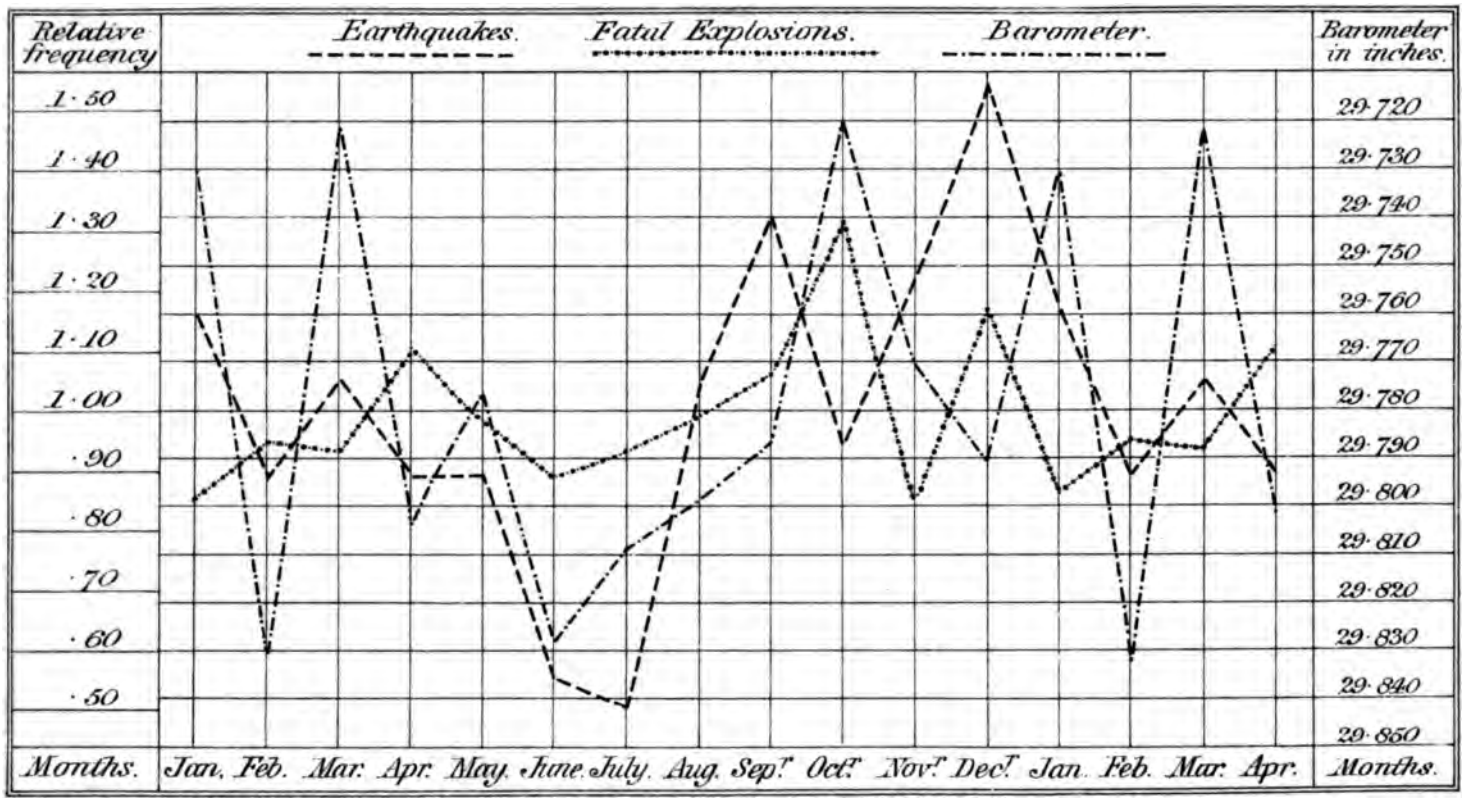
Reference

Seismic bands in Shades, shewing the position and relative intensity ..... a

Volcanoes Fumaroles, &c. ..... f

Areas of Subsidence [illegible]

To illustrate Mr. M.W. Brown's paper "On the observation of Earth-shakes or Tremors, in order to foretell the issue of sudden outbursts of Fire-damp".



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And. Reid, Newcastle.

2.—The observation of delicate levels.

3.—The observation of earth currents.

4.—The observation of the movements which take place in the roof and floor of the workings.

5.—The observation of the electrical condition of the air of the mine, accompanied with those of the barometer, thermometer, and the rise and fall of the tide.

There are many other circumstances which regulate the issue of gas, which might suggest an increase in the number and extent of these observations, but those set forth appear to be worthy of some consideration.

Professor LEBOUR said, he need not say that he did not agree in the slightest degree with Mr. Brown in his suggestion that the Sunderland earth-shakes or tremors were the results of what was stated in the paper. He believed that the so-called earthquakes at Sunderland were not earthquakes at all, but were due to local disturbances. But setting all this aside, he thought Mr. Brown's observations were of the highest possible interest, and it would be an excellent thing for this Institute to make inquiries as to these earth-tremors. The instruments necessary for making the observations were not complicated. The only difficulty was how to set them in work; and it could be done in this district by colliery proprietors lending parts of their pits in which to place the instruments. Observations were being made in other countries, and especially in Japan where there was a net-work of them. To register the earth-tremors was quite possible, and he thought it came within the scope of such an Institute as this to work the question out, and see, after a series of observations, whether there was any connection between explosions of gas and such earth-tremors.

The PRESIDENT said, the discussion of the paper would be adjourned. No doubt the Council would consider whether the observations which had fallen from Professor Lebour in regard to registering earth-tremors should bear any practical fruit. He was not aware that they had earth-tremors in such magnitude as to require a record; but possibly Professor Lebour would know better than he did. He proposed a vote of thanks to Mr. Brown for his paper.

The vote of thanks was agreed to, and the meeting concluded.

PROCEEDINGS.

ANNUAL GENERAL MEETING, SATURDAY, AUGUST 2ND, 1884, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

GEORGE BAKER FORSTER, ESQ., PRESIDENT, IN THE CHAIR.

MESSRS. C. C. Leach, T. E. Jobling, and Thomas Bailes, were appointed scrutineers to examine the voting papers for the election of officers for the year 1884-85.

The SECRETARY read the minutes of the last General Meeting and reported the proceedings of the Council.

The annual reports of the Council and Finance Committee were also read.

The following gentlemen were elected, having been previously nominated:—

ASSOCIATE MEMBERS—

Mr. T. SHIPLEY, M.E., New Copley Colliery, Cockfield.

Mr. EDWARD ROBERT FISHER, M.E., Cleveland Terrace, Walters Road, Swansea.

STUDENT—

Mr. GEORGE EDWIN JAMES MCMURTRIE, Towneley Collieries, Ryton-on-Tyne.

The following paper on "The Endless Chain in Spain," by Mr. George Lee, was then read:—

THE ENDLESS CHAIN IN SPAIN.

By GEORGE LEE.

The means employed in Spain for conveying ore from the mines, (which are generally situated at high altitudes, at or near the summit of the hills), to the smelting works on the lowlands, to the shipping places on the river or coast, to the lines of locomotive railway that supply the means of transport (when the intermediate country does not present any serious obstacle in the way of their construction), or to the public railway communicating with the point of destination, are many and of great variety. The only means that existed in the chief mining district of Bilbao previous to 1873, at which port during the preceding year 689,700 tons of iron ore had been shipped, were donkies or mules with panniers, and bullocks with carts, which, though tedious and costly, were the most available. Recently the mechanical and more economical appliances of self-acting inclined planes down which the mineral is lowered in sets of tubs or wagons, in hopper-bogies, in trucks, or in trucks on platforms (chiefly on heavy gradients, reaching so far as one in one-and-a-quarter); of engine planes; and of suspended endless ropeways (air-lines as they are locally called) have been adopted. There are two systems of endless ropeway in use, the first introduced, the simplest, and the one chiefly adopted being the single hauling rope with depending buckets, and the fixed suspended rope, with an endless hauling rope. The latter system possesses the advantage of not being affected by the wet or damp weather so prevalent in the north, which causes the saddles of the pendant buckets that grip on the travelling rope of the first system to lose their hold, and allow the buckets and saddles to glide amain, on the rope approaching an inclination of one in four. In addition there are endless chain railways and locomotive railways of different gauges, including one metre, forty-five inches, and the unfortunate national selection of sixty-six inches. The only excuse for the existence of the latter is that it was adopted for state reasons.

During recent years, many of the most approved systems of haulage common to mining, specially designed to meet particular requirements, and the more universal ordinary methods have been adopted, yet there is a prevalent want of experience in their general application. The market values of the ores have decreased, whilst the cost of mining, owing to increased depth and other difficulties attending the exhaustion of the mineral, is continually on the increase, reducing the margin between expenditure and revenue available for profits: there will be, doubtless, efforts made to meet the demand there exists for economy, with the result, that much of the present waste will disappear and the savings realized will so enhance the value of mining property generally that much which is now a burden to capitalists may become desirable investments.

The endless chain system of haulage, most recently introduced into Spain, is one with which engineers at home are well acquainted, its merits having been often tried and duly appreciated. The endless chain has been extensively adopted under circumstances where the existence of physical conditions presented difficulties in the way of the installation of other, and perhaps rival systems, but of less moment to its peculiar general adaptability.

The circumstances which led to the selection, the construction, and the application of the first endless chain railway that worked in Spain, to the requirements of the Anita mine, whose produce it is intended to convey, are chosen to form the subject of this paper.

In a sheltered cove on the north coast of Spain, in the province of Santander, at a distance of two miles to the east of Castro-Urdiales, lies Dicido, in whose bay is situated Avellanosa with its quay, from which the ore brought down from the Anita mine is shipped.

Previous to the starting of the endless chain on March 3rd, 1883, the ore was brought down by means of an air-line 1,600 yards in length, which was abandoned owing to the failing condition of the woodwork. This line, crossing a valley and the estuary of the river in its course, required very high piers for its support, which could only have been repaired at great cost. The existence of the difficulty mentioned previously, *i.e.*, the gliding amain of the saddles and buckets where the inclination of the rope in crossing the water exceeded the maximum at which the saddles retain their grip in all weathers, and the desire to provide means of transport more adequate, more certain, and more suitable for the future working of the mine, and the conveyance of a much greater output, led to the study and completion of the present railway.

The Anita deposit of iron ore is of that class distinguished as a vertical segregation, differing from the lode by the irregularity of its form, and further specially defined as a contact mass, being found between compact crystalline limestone (nummulitic in the higher altitudes) on the east, forming the hanging wall; blue schistose rock and yellow beddy marlstone on the west, forming the footwall. Its strike is towards true north; a line of mineral being traced from the cave in the rocks on the coast, out of which the mineral, being softer than the rocks, has probably been washed, through the present Station D (see Plate XVI., Figs. 1 and 2) to the quarries that are opened on the run, through the whole length of the Anita-take, through the Ceferino-take, where the mineral has been well exposed, to the deposits at Las Muñecas: here the mineral on the Sappho-take stands boldly out on one side of the valley, forming an escarpment, and from thence to the Galdames mines; in all, a distance of over seven miles. The portion of the run at present being worked, and with which it is proposed to deal, is the north end. For getting the ore from here to the shipping place on the coast, there were many schemes suggested and entertained by the different parties who from time to time have been interested in the development of this valuable property. At one time the project was to put down a narrow gauge locomotive railway from O to P; this would have been fed by self-acting inclines communicating with the quarries and adits at the different heights that the gradual exhaustion of the mine would entail; then by an incline of steep gradient from O, passing under the royal road and over the estuary, land the mineral at Dicido; but owing to the stupendous nature of the works of the latter part of the project, inclusive of a bridge of large span, the whole was abandoned.

After duly considering the steep slopes and deep ravines of the mountain-side with the intervening ridges, and the danger of interfering with the royal road, kept in a high state of efficiency by vigilant engineers, together with the difficulty of crossing the estuary and encountering the obstacles presented by the peculiar geological structure of the cliff between Dicido and Avellanosa, and on the other hand weighing with great care the facilities which other means of transport offered to the present and future requirements of the mine, which had to be attacked at various points and constantly at lower levels, it was thought that no system offered advantages equal to those of an endless chain.

After consulting the existing plans of the property and ascertaining the approximate heights by the aneroid, it was decided that 30 per cent., or 300 millimetres per metre, should be the maximum gradient, and

twenty-five millimetres the maximum size of the chain; the train of tubs was also fixed at about 35 per cent. of a load of 500 kilogrammes, each tub placed at a distance of 20 metres centre and centre, so that, if possible, the chain should ride clear of the sleepers, and the whole should work automatically: the direction that the lines ought to take, and the locality of the angles were determined: then pegs were driven at regular distances over the whole route from the quay to the top quarry at the mine, and levelling began on the 30th of April, 1882.

The plans of a railway and its various works that accompany the petition to the Government for the privilege of having them declared of public utility must be prepared to the metre scale, because Spain having established a metrical system of weights and measures of the same standards as those of France, the works have to be constructed accordingly, and all dimensions are in metres of 39·37079 English inches, and all weights in kilogrammes of 2·20462 English pounds. In expressing the value of the inclination or gradient, instead of using the terms 1 in 33, 30 per cent., or 300 millimetres per metre, the simple figures ·300, as expressing the millimetres rise or fall per metre will be used.

[illegible]lts of the levelling are given in the following Table:—

Wheels, Stations, or Angles.		Lenc[illegible]						Sections.			
Designation.	Height above High Water Mark.	Designation.	Length.	Fall.	Rise.	Inc[illegible] Average.	Inc[illegible] Maximum.	[illegible]tion.	Length.	Fall.	Average Gradient.
	Metres.		Metres.	Metres.					[illegible]s.	Metres.	
A	347·48										
A^1	318·68	A A^1	180·85	28·80	...	0·159	0·226	A	180	28·80	0·159
B	260·57	A B	693·58	58·11	...	0·083	0·270	B	1,044·76	1[illegible]	0·107
C	206·63	B C	351·18	53·94	...	0·153	0·269				
D_C	119·67	C D_C	617·56	86·96	...	0·141	0·300	C	617·56	86·96	[illegible]41
D	119·42	D_C D	12·50	·25	...	0·020					
E_D	65·28	D E_D	375·60	54·14	...	0·144	0·300	D	1,151·65	107·01	0·093
E	51·78	E_D E	20·00	13·50	...	Drop.					
F	2·97	E F	395·25	48·81	...	0·123	0·220				
G	7·53	F G	180·80	...	4·56	0·025	0·120				
H	12·41	G H	180·00	...	4·88	0·027	0·120				
			3,007·32	344·51	9·44	0·114					

In proceeding to ascertain the tensions that the chains will have to endure at the projected wheels, and considering that the dimensions of the tub, its weight, and its load, are important quantities in the cal-

culations to follow, it is better to describe them now. Two views of the tubs are shown on Plate XVII., Figs. 1 and 2; the general design is adapted more for mining purposes than for open quarry work, which is the only means required to win the ore for some time to come: until the time arrives when they will be required to go underground and meet all the necessities of mining, it is unnecessary to provide them with coupling chains. The inside dimensions of the box are 1 metre long by ·64 metre wide and ·45 metre deep, or a capacity of ·288 cubic metre, capable of containing when level full 508 kilogrammes of iron ore. The box is made of poplar deals ·040 metre thick, furnished at the top with an angle iron hoop, giving additional strength to the hind end of the tub that has not only to support the chain, but to resist the retaining effect of the chain on the gradient approaching the leading-on pulleys when the chain has left the fork; also to withstand the rubbing of the chain, which by accident may be lifted out of the fork, when on heavy gradients the tub acquires at once a velocity too great to allow time for the vertical link to fall the depth of the fork, and the tub is only slightly retarded by the friction caused by the passage of the chain's uneven surface over the two ledges (the fork, and the hind end of the box) and escapes until stopped by the tub next below. To receive such shocks as those the box ought to be strong and well secured to the tram, consequently there are six angle-iron vertical straps having hold of the top hoop, and the intermediate sides or ends of the box are bolted to the oaken soles of the tram. The fork consists of an ·030 metre thick iron plate presenting an opening of ·160 metre, down whose sides, at an angle of 35° the chain glides into a notch ·075 metre by ·027 metre prepared for the reception of the vertical link. To each side of this plate is riveted a ·06 metre angle-iron, which in its turn is riveted to the top hoop, the pair expanding pass beneath the end transverse piece where they are bolted to the inside of the sole. The wheels are of cast steel ·271 metre diameter, with steel axles, a set (pair of wheels and axle) weighing 24 kilogrammes, the total weight of the tub being 180 kilogrammes. In lieu of corner posts or plates, each corner is provided with two straps whose ends are riveted to the vertical ones. The height of the tub above the rail is ·82 metre, and ·07 metre being the height of the rail, the top of the tub, being the resting place of the chain, is ·89 metre above the surface of the sleeper.

According to the Table (page 193) the greatest tension will be at C on the length C D_c. In finding that tension it is better to reduce the weight of the tub 180 kilogrammes, the load 500 kilogrammes, and the chain

12·65 kilogrammes per metre, to the weight of a lineal metre of train: then $\frac{180+500}{20} + 12{\cdot}65 = 46{\cdot}65$ kilogrammes weight per metre of full train, and $\frac{180}{20} + 12{\cdot}65 = 21{\cdot}65$ kilogrammes weight per metre of empty train. Taking from the table the fall of 86·96 metres, and the length of 617·56 metres, all that is required to complete the calculation is the mean co-efficient of resistance of the full and empty trains; and this, as the tubs and rails were new, was necessarily an estimate, guided by experience and actual experiment with other and similar tubs, giving it as low as ·018, it was decided to allow a margin in favour of the starting of the new work, and ·025 was fixed as representing it.

	Kilogrammes.	
46·65 × 86·96 =	4,056·68	
46·65 × 617·56 × ·025 =	720·22	
	3,336·46,	tension on full chain, and
21·65 × 86·96 =	1,882·68	
21·65 × 617·56 × ·025 =	334·25	
	2,216·93,	tension on empty chain.

To these tensions must be added 500 kilogrammes sustaining tension, indispensable at the loose pulley D_c, for the purpose of keeping the chain in suspension, which, having been gradually relieved of the weight of the train, would otherwise droop and trail on the sleepers, hence (3,336·46 + 500 =) 3,836 kilogrammes is the greatest working tension on the line.

Then according to the common formula, $D = \sqrt{9\,W}$: D being the diameter in eighths of an inch, and W the safe load in tons: a chain of 5·83 eighths of an inch diameter is sufficient for the working load of 3,836 kilogrammes; then, taking into account the severe shocks and strains that a chain riding on gradients so steep as those shown in the table is liable to, from unavoidable causes, a one-inch chain, or the nearest approach to that size, 25 millimetres was selected for the six heavy lengths, and an 18 millimetre chain for the two flat lengths F G and G H.

The sustaining tension applied at the ends, or at any other point on a length where the effect of the weight of the train becomes insufficient to support the chain free of the sleepers, being an additional strain the effect of which is transmitted over the entire length, ought to be applied cautiously. With the exception of the long flat above F, 500 kilogrammes

is a maximum quite adequate for the object as far as the rest of the heavy lengths are concerned. For the lighter chain and flat length 300 kilogrammes is the quantity used in ascertaining the tensions or working loads of the eight chains at their respective wheels, and which are given in the following Table:—

Wheel.	Down.			For the Control of the Fan-fly.	Up.		
	Full Side.	Empty Side.	Total.		Full Side.	Empty Side.	Total.
	Kilogs.	Kilogs.	Kilogs.	Kilogs.	Kilogs.	Kilogs.	Kilogs.
A	1,632	1,221	2,853	411	...	...	...
A′	2,302	2,302	4,604		500	500	1,000
B	2,606	1,857	4,463	1,418	500	1,169	1,669
C	3,836	2,716	6,552	1,120	500	500	1,000
D_C	...	...	...	...	500	500	1,000
D	2,587	1,980	4,567	607	...	...	...
E	2,316	2,421	4,737		500	605	1,105
F	300	951	1,251		500	1,151	1,651
G	300	628	928		623	951	1,574
H	...	...	...		634	634	1,268

In determining the profile, or line, which the formation for the reception of the way should be constructed to, the value of many of the forces had to be estimated, but after deciding what should be aimed at in designing the works in detail, these estimates were practically all that was requisite, though in showing the method pursued, the actual value of the forces, &c., as since ascertained, will be employed:

	Kilogrammes.
Weight of load (mineral carried by tub)	500
„ tub	180
„ 25 millimetre chain per metre	12·65
„ 18 „ „	6·60
„ full train with 25 millimetre chain per metre	46·65
„ empty „ „ „ „	21·65
„ full train with 18 „ „ „	40·6
„ empty „ „ „ „	15·6
Coefficient of resistance	0·025
	Metres.
Distance between centres of tubs in train	20·
Span, being the space between the tubs	18·90
Half-span	9·45
Top of tub, or point of suspension above the sleepers	0·89
Height of rail	0·07
„ fork above rail	0·93

In the construction of the railway whose total length will be between the wheel A and H, 3,007·32 metres (3,288·80 yards) possessing a total fall of 344·51 metres (1,130·26 feet), giving an average inclination of ·114, or 1 in 8·72, one object has been to avoid the introduction of abrupt changes of gradient, the presence of which in the profile would prove impediments in the endeavour to so harmonize the concavities and convexities in the line of rail to the deflexion assumed by the chain under its varying tension in the many spans comprised in the length of a train, that the chain may ride free without trailing.

The tension required to sustain the 25 millimetres chain on the span of 18·90 metres, the points of suspension being ·89 metre above the horizontal line over the tops of the sleepers:

$$\cdot 89 = \frac{12\cdot 65}{2\,\mathrm{T}}\,9\cdot 45^2\,;\ \mathrm{T} = \frac{12\cdot 65 \times 9\cdot 45^2}{\cdot 89 \times 2} = 634 \text{ kilogrammes tension}$$

required. For the 18 millimetres chain, 331 kilogrammes is the tension required.

In deciding on the principal points in the profile of a length, it is best to fix upon the form of the bank-head and bank-foot first, not only because their establishment affects the connecting profile, but because at these two points the chief causes of friction exist, the effect of which it is the duty of the engineer to avoid altogether, or reduce to a minimum in dealing with natural obstacles, so far as a due regard to economy will permit. In order that the chain should rest as lightly as possible on the leading-off pulley *a* in the bank-foot (see Plate XVII., Fig. 3), *a* ought to be the lowest point of the curve assumed by the chain under a tension of 500 kilogrammes; then, taking the distance of the last departing tub from the pulley, when the following tub should take the chain, to be 20 metres:

$$\frac{500}{12\cdot 65 \times 20} = 1\cdot 97 \text{ kilogrammes,}$$

the coefficient of tension at *a*, being the lowest part of the chain; then

$$\frac{20}{1\cdot 97 \times 2} = 5\cdot 07 \text{ metres,}$$

the deflexion of the chain, or the height of the point of suspension *c* above the pulley *a*; then

$$\frac{2 \times 5\cdot 07}{20} = \cdot 507,$$

which is the tangent at *c*.

$$\text{Log. } \cdot 507 = \bar{1}\cdot 705008$$

$$\underline{10}$$

$$9\cdot 705008 = \text{log. tan. of } 26^\circ\ 54',$$

the angle made by the chain with the horizon at its point of suspension, or, in other words, an inclination of ·507.

The mechanical curve that a chain of uniform substance and texture assumes when it is hung upon two points (whether those points be in a horizontal plane or not) is a catenary one; but designing is made easier and the construction unaffected if the curve is considered a parabola.

The present curve will then be, $\frac{5{\cdot}07}{20^2} = {\cdot}012675$, say a parabola $a\,b\,c$ of $\cdot 0127x^2$, x being the ordinate.

The maximum inclination that can be accepted being ·300, it is necessary to find at what part of the parabola its tangent will have such an angle or inclination:

$$\frac{\cdot 300}{\cdot 0127 \times 2} = 11{\cdot}81 \text{ metres,}$$

the distance from a to b, the point of departure of the tangent $b\ d$ of ·300; d being ·83 metre below c.

With the point of suspension at d, the angle in the chain caused by the pulley a, is $2^\circ\ 17'$; this is the least (the quantities remaining the same) that it is possible to have.

If the bank-foot were at a terminus the rails could be laid to work to these lines; but, in order that the description may afford a more general application, it is supposed to be at an angle or station. The chain passes over the pulley a at a height of 1·22 metres above the rail, or ·40 metre above the top of the tub (this height is determined by the height of the pulley ·13 metre diameter on the full side of the length in front; it is likewise the minimum height at which the larger pulley of ·276 metre diameter can be placed to clear the forks), consequently the chain on passing the pulley a must be allowed to droop so as to meet the line $e\,f\,g$ that the top of the tub takes, acquiring sufficient momentum on the inclination ·020 to carry it along the level $f\,g$ which is ·47 metre beneath a:

$$\frac{\cdot 47}{\cdot 0127} = 37{\cdot}16,\ \sqrt{37{\cdot}16} = 6{\cdot}08 \text{ metres,}$$

the distance from a to g, where the vertex of the parabola must be placed.

The necessary momentum to carry the full tub over the flat sheets to the point of attachment on the length in advance is acquired by its becoming detached from the chain on the gradient ·025.

Whether it be a bank-head or a bank-foot that is being designed, it is of the greatest importance to minimize the friction at the leading-

off and leading-on pulleys. (See Plate XVII., Fig. 4.) In forming a bank-head (with the load) it is best to continue the level of the flatsheets to a point that the last departing full tub reaches when the following tub arrives at the point of attachment, and the distance of the former from the leading-off pulley is arrived at as follows:—

Tension at brake-station D (see Table on page 193) 2,587 kilogrammes. $\frac{2{,}587}{12{\cdot}65 \times 9{\cdot}45} = 21{\cdot}64$ kilogrammes the coefficient of tension; then $\frac{9{\cdot}45}{21{\cdot}64 \times 2}$ $= {\cdot}22$, the deflexion of the chain resting on the tubs at the working span of 18·90 metres.

The curve assumed by the chain is a parabola of $\frac{{\cdot}22}{9{\cdot}45^2} = {\cdot}0024$; a parabola of ${\cdot}0024x^2$.

On a flat bank-head a pulley of ·13 metre diameter may be used advantageously at the following height:—

	Metres.
Height of fork	0·93
Clearance	0·0275
Diameter of pulley	0·130
Centre of chain above pulley	0·0125
	1·1000
Height of centre of chain on top of tub	0·86
	0·24

Then, $\frac{{\cdot}24 + {\cdot}22}{{\cdot}0024} = 191{\cdot}666'$; $\sqrt{191{\cdot}666'} = 13{\cdot}84$ metres, the distance of the lowest part of the suspended chain from the pulley, or $13{\cdot}84 - 9{\cdot}45$ $= 4{\cdot}39$ metres from the pulley to where the chain will be at rest in the fork; but as the chain takes hold of the fork when the link is ·05 metre from home, the point of attachment is practically at 3·33 metres in front of the pulley. The level forming the bank-head, including the 1 metre that the pulley is distant from the chain wheel, is then 23·23 metres; it is tangential to the summit of a curve connecting the profile of the length to the bank-head; a curve of less radius forms the kip for the empty side, 2 metres short of the leading-on pulley, under the guard bars of which a gradient of ·025 is sufficient to accelerate the momentum already imparted to the tub by the chain and deliver it at the point of attachment in the bank-foot.

It is not at all times that such a desirable bank-head can be constructed as that erected at D, where the difficulties of a gorge and a steep mountain-

side rendered it expedient to modify it materially, and as a substitute to establish a curve that would only admit the full chain to ride without dragging:

	Metres.
Height of point of suspension	·89
Deflexion of chain ·22 + ·02 metre for clearance ...	·24
Available rise	·65

Then, $\frac{9{\cdot}45^2}{{\cdot}65} = 137{\cdot}38$ metres which being divided by 2 gives 68·69 metres as the radius of the curve. In order to take advantage of the extra play which the use of round numbers would give, the radius was taken at 70 metres, which gives

$$\frac{18{\cdot}9^2}{70 \times 2} = 2{\cdot}55 \text{ metres}$$

the distance that the point of suspension on the tub *a* is below the point on the tub *b*.

Such a bank-head must be provided with pulleys of large diameter to meet the friction caused by the increased angle of deflection of the chain, which has to adapt itself to the train on a curve of such great fall; therefore, 1·29 metres between the centre of the chain and the rail is allowed, which is sufficient for pulleys of ·276 metre diameter; then the difference in height between the chain in the fork of the tub *b*, and the chain on the pulley *p*, the outside dimensions of the links being ·138 × ·081 metre, will be

$$1{\cdot}29 - {\cdot}82 = {\cdot}47 \text{ metre}, {\cdot}47 - (0{\cdot}081 \div 2) = {\cdot}4295.$$

$\frac{\sqrt{{\cdot}4295 + {\cdot}22}}{{\cdot}0024} = 16{\cdot}45$ metres, the horizontal distance between the vertex of the curve described by the chain and the pulley *p*, assuming the train to be on a level; but the difference in the heights of the tubs *a* and *b* is equal to an inclination of ·119; therefore the distance will be 16·45 − 4·93 = 11·52 metres. Then 11·52 − 9·45 = 2·07 + 1 (the distance from the wheel to the pulley *p*) = 3·07 metres from the centre of the wheel to the point of attachment, which is also the summit of the curve, whose length to unite the level at this point to an inclination of ·30 is:

$$\begin{array}{ll} \text{Log. of } {\cdot}30 & \bar{1}{\cdot}477121 \\ & 10{\cdot} \\ \hline & 9{\cdot}477121 = \text{log. tan. of } 16^\circ\ 42' \end{array}$$

Half the angle of intersection of this angle and a horizontal line is :

$$\frac{180^\circ - 16^\circ 42'}{2} = 81^\circ 39' = 4{,}899'$$

$$(5{,}400 - 4{,}899) \times \cdot 000582 \times 70 = 20\cdot 41 \text{ metres,}$$

the length of the curve. The tension of the chain on the empty train (see Table on page 193) is 1,980 kilogrammes, and

$$\frac{1{,}980}{12\cdot 65 \times 9\cdot 45} = 16\cdot 56 \text{ gives the coefficient of tension,}$$

and $$\frac{9\cdot 45}{16\cdot 56 \times 2} = \cdot 28 \text{ the deflexion.}$$

Now the rise of the curve $\cdot 28 + \cdot 65 = \cdot 93$ metre, and as this exceeds the height of the point of suspension by $\cdot 04$ metre it will be necessary to place rollers between the rails to receive the chain and prevent it trailing on the ground. The distance that these rollers ought to be placed apart to support the chain $\cdot 132$ metre clear of the sleepers, treating the deflexion on so short a span as the curvature will establish as an unimportant quantity, will be $\sqrt{\cdot 132 \times 140} = 4\cdot 30$ metres. To provide a kip, a suitable point on the curve is chosen at *m*, 7 metres from the summit, where the tangent possesses $\frac{7}{\sqrt{70^2 - 7^2}} = \cdot 100$ inclination, this is continued for $2\cdot 07$ metres to the height of $9\cdot 86$ metres and 8 metres from the wheel, then a curve of 40 metres whose summit will be

$$\cdot 100 \times 40 = 4 \text{ metres further, and}$$

$$\sqrt{40^2 - 4^2} = 39\cdot 80 - 40 = \cdot 20 \text{ metre will give the}$$

height of the summit above *m*; the curve is then continued to *n*, 3 metres from the wheel from where its tangent having an inclination of $\cdot 025$, is continued to the flat-sheets.

To show the arrangement of curves, parabolas, and planes, all tangentially united, which constitute the profile of a railway passing through a piece of country so remarkable for the abruptness of its lines of configuration as that intervening between the Anita mine and Avellanosa, the length taken as an example is that of C D_C (see Plate XVI., Fig. 3) because it presents the chief difficulties that had to be surmounted. From A to C there were not many difficulties encountered in forming the line at a convenient distance from and parallel to the run of the mineral, so as to meet the future demands that mining the ore at lower depths would entail. From A to B it was mostly made by the shovel, which the peasants had to be taught to use, in the form of a ledge in the

mine-refuse lying on the mountain-side at its natural slope of 45°. The embankment below B was formed of refuse conveyed from the heap by tub and tram.

It was decided that the best way of contending with the hill and ravine below C was to pierce the former with a tunnel (see Plate XVII., Fig. 5); and with the stones won in driving it, together with the stones produced by the cutting on the opposite ridge, to form a dry wall embankment after the manner shown in Plate XVII., Fig. 6). These walls were adopted in preference to wood-work, which was avoided as much as possible on account of its short life in a climate which produces rapid decay in the poor pine that it is usual to import, and the impossibility of procuring carpenters who have had any experience in erecting such work. In the construction of the walls, the knowledge that the local masons and the peasantry of the neighbourhood possess and their skill in dry-walling were utilized.

Where the blue schistose rock, which crumbles after long exposure to the weather, has been used, the walls (provided with weeping-holes) were plastered with lime for their protection. On the high side of these embankments where the ditch could not be cut in clay, or where the formation is above the natural surface, adequate means were taken for preventing the surface-water from penetrating among the stones of the bank by covering them with earth and providing a collecting ditch to convey away the water.

The water-ways in the embankments are vertical openings between transverse buttresses which give additional strength to the whole.

Having estimated the resources for stone, examined the ground, and decided that the height of the embankment ought not to exceed 1 metre at peg 154 (See section C D_C, Plate XVI., Fig. 3), then, in order to find the curve the chain would assume suspended across this hollow, it was necessary to find first the tension of the chain on the full train, which, as the curve was concave, was the greatest tension required.

The peg (Plate XVI., Fig. 3), is 180·57 — 119·67 = 60·90 metres above, and 1,537·67 — 1,164·15 = 373·52 metres from the terminus at the loose wheel D_C; then

	Kilogrammes.
46·65 × 60·90	= 2,840·98
46·65 × 373·52 × ·025 =	435·62

2,415·36 + 500 = 2,915 kilogrammes the tension on the full chain. With this tension, and a span of 18·90 metres, the deflexion will be $\frac{12{\cdot}65}{2{,}915 \times 2} \times 9{\cdot}45^2 = {\cdot}1937$; then with

this rise the curve will be $\frac{\cdot 1937}{9\cdot 45^2}$ = a parabola of $\cdot 00217x^2$. From peg 154 going towards C, guided by a section over the line of pegs of equal horizontal and vertical scales, it was found convenient to introduce a plane having an inclination of ·17 as a tangent to the parabola of ·002, although, perhaps, it would have been better to have allowed a little more play for accidental strains which, by reducing the deflexion, might have lifted the chain out of the forks and caused the tubs to run together, but the disadvantages attending any increase in the height of the embankment did not admit of this; then

$$\cdot 17 = 2 \times \cdot 002x, \text{ and } x = 42\cdot 5 \text{ metres}$$

the distance that the parabola will occupy in the profile, and the height

$$\cdot 002 \times 42\cdot 5^2 = 3\cdot 612 \text{ metres.}$$

As it was convenient to have the formation at a point fixed at a distance of 1,580·22 metres, with the rails at a height of 184·19 metres, the vertex of the parabola was 184·19 — 3·62 = 180·57 metres at the distance of 1,537·67 metres; the inclination of ·170 was continued for 15·45 metres, x being 1,595·67 and y 186·81 metres. At this point a curve is introduced to join the inclination of ·1187 being the inclination of the tunnel best adapted to suit peculiarities in the beds of the rock, offering good roofs for the mouths of the tunnel.

$$\begin{aligned} \cdot 17 &= 9^\circ\, 53' \\ \cdot 1187 &= 6\ \ 49 \\ \hline & 176\ \ 56 \div 2 = 88^\circ 28' \end{aligned}$$

half the angle, of intersection.

Selecting a curve of 200 metres radius: 88° 28′ = 5,308′; then (5,400 — 5,308) ·000582 × 200 = 10·70 metres the length of the curve: the point of intersection of these two lines x = 1,595·02 metres, and the curve will extend from x = 1,595·67 metres to x = 1,606·37 metres a point 4 metres inside of the northern mouth of the tunnel. To ascertain the height of these points:

$$15\cdot 45 \times \cdot 17 = 2\cdot 62 + 184\cdot 19 = y = 186\cdot 81 \text{ metres; } x = 1{,}595\cdot 67 \text{ metres.}$$

To arrive at the value of y, x = 1,606·37 metres, find the offset from the tangent ·17 to an arc of a curve of 200 metres radius whose chord is 10·70 metres,

$$10\cdot 70 \times \cdot 17 - \frac{10\cdot 70^2}{200 \times 2} = 1\cdot 53 + 186\cdot 81 = 188\cdot 34;$$

$$y = 188\cdot 34 \text{ metres, } x = 1{,}606\cdot 37 \text{ metres.}$$

The tunnel 104 metres in length, 2·30 metres wide, and 1·90 metres high (see Plate XVII., Fig. 5) was driven from both ends, through the blue schistose rock of the district, and did not need any lining of masonry.

Returning to $x = 1{,}537{\cdot}67$ metres, and proceeding towards D_C, as the ridge in front did not present any great difficulty a parabola much flatter than that on the south side was employed, and one of $y = {\cdot}0015\ x^2$ having a tangent of ·125 was chosen; then

$$\frac{{\cdot}125}{{\cdot}0015 \times 2} = 41{\cdot}66 \text{ metres} = x,$$

and $$41{\cdot}66^2 \times {\cdot}0015 = 2{\cdot}60 \text{ metres} = y$$

with this the point $x = 1{,}537{\cdot}67 - 41{\cdot}66 = 1{,}496{\cdot}01$ metres and $y = 180{\cdot}57 + 2{\cdot}60 = 183{\cdot}17$ metres. Wishing to utilize a certain quantity of suitable building stone that showed itself on the line of the route over the ridge, the rock was cut the full width of the formation. The tension of the empty chain at this point was

	Kilogrammes.
$183{\cdot}85 - 119{\cdot}67 = 64{\cdot}18 \times 12{\cdot}65$	$= 811{\cdot}87$
$1{,}490{\cdot}57 - 1{,}164{\cdot}15 = 326{\cdot}42 \times 12{\cdot}65 \times {\cdot}025$	$= 103{\cdot}23$
	$708{\cdot}64 + 500 = 1{,}208$

kilogrammes. Then $\frac{12{\cdot}65}{1{,}208 \times 2}\, 9{\cdot}45^2 = {\cdot}467$ metres the deflexion of the chain,

$${\cdot}89 - 4{\cdot}67 = {\cdot}423 \text{ metre}$$

the available maximum rise, $\frac{9{\cdot}45}{{\cdot}467} = 191{\cdot}22 \div 2 = 95{\cdot}61$ metres, the radius of the curve, an arc of which whose chord is 18·90, has a rise of ·423 metre, consequently the curve of 135 metres adapting itself to the surface was introduced advantageously.

The summit of a circle of 135 metres, whose tangent is at an inclination of ·125 with the horizon, will place itself in

$${\cdot}125 \times 135 = 16{\cdot}875,\ \sqrt{135^2 - 16{\cdot}875^2} = 133{\cdot}93 \text{ metres.}$$

$$133{\cdot}93 \times {\cdot}125 = 16{\cdot}74 \text{ metres.}$$

Then $x = 1{,}490{\cdot}57 - 16{\cdot}74 = 1{,}473{\cdot}83$ metres, and $y = 135 - 133{\cdot}93 = 1{\cdot}07 + 183{\cdot}85$; from this point the curve is continued until $y = 1{,}444{\cdot}43$ metres:

$$1{,}473{\cdot}83 - 1{,}444{\cdot}43 = 29{\cdot}40 \text{ metres,}$$

$$\frac{29{\cdot}40^2}{135 \times 2} = 3{\cdot}20 \text{ metres,}$$

$$y = 184{\cdot}92 - 3{\cdot}20 = 181{\cdot}72 \text{ metres.}$$

Between the point $x = 1{,}444{\cdot}43$ metres and $x = 1{,}294{\cdot}63$ metres the profile follows the surface closely, the object being to excavate just sufficient on the high side of the centre line to form the embankment for the half of the formation on the low side, because the steep mountain side did not

carry more. Both here and on the length D E below, great precaution had to be taken to prevent the earth and stones when once set in motion escaping and bounding down the hill, on to and over the road beneath to the beach. Approaching D_C is a length of 64·03 metres having an inclination of ·30 metre, which is the longest length of the maximum gradient; on this the average depth of cutting is 1·290 metres, mostly rock which was utilized in ballasting the adjacent lengths. At the foot of this gradient is a parabola of ·005; it is much flatter than the chain required, in order to save the cost of an embankment which would have been required if the cutting had been dispensed with. The point at which the loose pulley D_C is fixed upon is determined with a view to meet the design of the brake station D (see Plate XVIII., Fig. 1).

The principal reason for deciding that the wheel D should be eight metres beyond A, the point of intersection of the centre lines of the two lengths C D_C and D E, is because of the immediate and abrupt fall that exists from A towards E, on which it would have been both difficult and costly to have erected the bank-head already described (see Plate XVII., Fig. 4). In placing D thus, the ends of the wooden beams that support the machinery have been let into and secured in the limestone rock in which the station is cut, thereby saving the cost of the walls of masonry that otherwise would have been needed for the purpose of receiving them. The rock detached, and the large stones from the cutting above D_C, were sufficient to form the dry wall embankment close at hand.

Station E (see Plate XVIII., Fig. 2) is situated on the side of the royal road. After some deliberation it was decided that a subway would be the means best adapted to overcome the various obstacles and meet the official requirements in dealing with the highway. This subway, 32 metres long, is lined throughout with pick-dressed limestone blocks; the side walls have a batter of 1 in 20, supporting an arch of 120° curvature, with a span of 2·30 metres; to reach the lower level, a break in the system was introduced, in the shape of an ordinary drop staple of 13·50 metres, situated at a distance of 5 metres from the line D E. The inside dimensions of the rectangular shaft were 2·75 metres by 1·50 metres, formed of three walls of masonry, two of which connect the outer and stouter wall to the cliff; so that the full tubs should leave the chain under the supporting pullies at E_D, gravitate on the flatsheets A to the banksman, who, in pushing the full tub into the cage simultaneously, would force out the empty tub on to the flatsheets B, where it would be received by a boy who would direct it towards E_D; at the bottom of the staple the onsetter on the side B acting similarly to the banksman above, would land the full tub on the

side A, where a man giving it the direction causes it to gravitate towards the flatsheets behind E. Although the rate at which the tubs land on the flatsheets A is one every 20 seconds, the dropping is easily accomplished and rendered easier for the workmen by hinging the rails on which the tub rests to the A end of the cage whilst the cage is at the top, the rails (on the top of which are fixed pieces of flat bar 1 centimetre thick, and just long enough for the wheels to span whilst at rest on the rails, also answering the purpose of snecks) retain a horizontal position assumed by virtue of well-fitting shoes that hold a good length of slide, but on arriving at the bottom the loose ends of the rails are received by a pair of chocks, when the weight of the tub brings the hinges into play, the rails acquire an inclination, cause the full tub to mount and land itself on to the flatsheets on the side A. The balance wheel (see Plate XVII., Figs. 10 and 11) has a rectangular groove 150 millimetres deep by 45 millimetres wide. Inserted in this groove and projecting through openings in the flanges are 12 blocks of wood of 160 millimetres by 165 millimetres by 120 millimetres, secured in position by a split pin passing through them on the outside of each flange of the rim. Out of these wooden blocks are sawn pieces in the form of isosceles triangles of 50° the angle at the vertex. These dents occupy the centre of the groove receiving the rope, which, by virtue of the weight of the load, is held firmly by the wheel and is controlled by the brake.

The chains on passing over the pulleys at E_D descend 10 metres and pass beneath bearing down pulleys that lead the chain horizontally, on and off the wheel E, on the end of the shaft and 3·25 metres above the wheel of the chain E F.

From the flatsheets at A there is a line of rails leading to a gangway on which there is a kick-up placed over a deposit or bunker cut in the rock; the bottom of the shoot is cut at an angle of 50° so that the ore tipped at the kick-up, banks and covers the platform below, in which and also in the front are two openings 45 centimetres wide. As the bunker fills these are closed with lengths of battens, and in filling the bullock carts in front or below the deals are removed one by one as required, allowing the mineral to tumble into the carts. Two openings are provided to obtain sufficient capacity in the bunker so that two carts can load at a time. This provision is made to meet the desirability of having always at Castro-Urdiales a stock of mineral upon or near to the quay at that port, which although it has to be taken there by bullock carts, has at times been found an advantage to load under the shelter of the promontory of Castro,

especially when a cargo has to be completed with despatch, and when the long prevalence of severe weather has rendered shipment impossible at Avellanosa.

The length E F, besides the cutting at the mouth of the subway and the three bridges, two over and one under the railway, does not possess any important feature as the line of profile throughout runs very near to the surface of the land.

On leaving F, the lowest point in the railway, the rails are only 2·97 metres above high water mark, and cross the estuary on a wooden bridge 80 metres in length, made of braced girders resting on piles; the railway then passes along on the top of the rocks, the side towards the sea being protected by a wall extending from the base of the pier to G.

Between G and H the railway crosses an angle in the sea wall on longitudinal beams running parallel to each other at such distances apart as to allow of the reception of the rails, thus dispensing with a platform which would offer too great a resistance to the waves that might be projected up the face of the wall in some of the heavy seas occasionally experienced. The longitudinal beams are supported by beams resting on, secured in, and held by bolts built into the wall, their opposite ends being supported and weighted to counteract that of the load. After crossing this, the railway runs along on the front of the cliff to the terminus H, 12·41 metres above high water mark.

The formation (see Plate XVIII., Figs. 3 and 4) is 3 metres wide, both on embankments and in cuttings. Very little ditch is needed, provision being made for collecting the surface water on the high sides of the slopes and directing it to the water ways prepared for its passage underneath the railway. The distance between the centres of the two lines of way of ·45 metre (17·71 inches) gauge, is 1·20 metres. Where the inclination and height of the two ways are equal, through-sleepers of native oak 2·20 metres long by 15 centimetres wide and 9 centimetres thick are used. The flat-bottomed rails specially made for the railway, and with which the lengths BC, CD, and DE are laid, are of Bessemer steel, weighing 12·40 kilogrammes per metre (25lbs. per yard) notched for joint spikes and holed for fish-plates. To avoid the unnecessary weakening of the inside plate, punched as is customary to receive square-necked bolts, the bolts have pear-shaped necks. The spikes are 75 millimetres long by 10 millimetres square, placed one per sleeper per rail, inside and outside alternately. Rather more than half of the railway is laid with flat-bottomed steel rails, weighing 20 kilo-

grammes per metre, that had been got for the locomotive line from O to P, and had to be used, and to save conveying their extra weight they were laid at the two ends of the line near to where they were lying.

The ballast used consists for the most part of stone obtained from the cuttings, broken by hand to the size of road metal. In some places it was not only cheaper but an advantage to use the refuse in the vicinity, which, owing to its nature after a little treading, becomes impervious to water and keeps the line immovably fixed after it has been once well topped.

As a precaution against the tendency there is in a way laid on steep inclinations to gradually move in the direction favoured by the incline, through the working of the ballast, a stout sleeper has been inserted at every third joint on the low side of the joint sleeper, to which the rails are fixed by spikes driven through holes specially drilled in the flanges of each rail; behind this, and on the inside of the outer rails are 45 centimetres iron bolts set in cement in holes drilled in the rock; where the ballast is refuse this is quite useless, as the notches in the rails hold to the spikes in the immovable sleepers; where there is neither rock nor this refuse, strong stakes driven into the ground behind a sleeper are sometimes used.

Excepting two or three places where it would have entailed more expense than was commensurate with the saving in wear and tear to be gained to have constructed the profile so that the chain should always ride clear of the ground without touching, there are a few rollers used to support the chain above the sleepers, and they are placed on the bank-heads at A and D, and at the F end of the subway, with odd ones in some of the bank-foots, useful when a chain loses the sustaining tension through wear, or during the excessive heat of mid-day when expansion produces the same effect. The rollers are formed of two tub wheels running loose upon an axle held by two cleats, whose ends are spiked to two adjoining sleepers, the space between them that receives the vertical link is adjusted by placing a washer between the nozzles of the bosses. (See Plate XVIII., Figs. 3 and 4.)

Behind the works at Dicido there is a bed of limestone possessing the proper combination of silica and alumina to yield a hydraulic lime in an eminent degree; this lime, manufactured on the place, has been used in the erection of the sea walls and piers, and has also been of good service in the erection of the walls for binding the wooden framework supporting the machinery at the different angles and stations where other means have not been employed.

Plate XVIII., Fig. 5, describes the manner in which the wheels and pulleys at the angles and stations are fixed, and a plan (Plate XIX., Fig. 1) is given, showing the brake-station C. The transverse beams are shown in the former as being cut on the line of the two lengths C B and C D_C, that intersect at the centre of the shaft of the chain-wheel A, shown on the latter. The masonry is rubble and small stones set in hydraulic lime, or what may be practically termed concrete. The principal walls that secure the ends of the two beams that together form a seat for the footstep, and the three beams placed ·10 metre apart, with intervening chocks through which the main carriage holding bolts pass, bracing the whole into one rigid support for the machinery, form a solid resistance against the tension towards D_C of 5,552 kilogrammes; these walls are 1 metre thick on the side that the tension is greatest, and the wing-walls for holding the pulley and guard-beams are ·60 metre and ·85 metre thick respectively.

The chain-wheel A rests upon a collar, and is keyed to the shaft with two keys placed at 120° apart. Resting upon this wheel is the loose-wheel B (see Plate XVII., Fig. 9), and above all clearing the transverse beams 5 centimetres is the brake and spur-wheel C; as the balance or pendulum regulates the works of a clock, the fan-fly, analogous in its properties and use, regulates the speed of the train on an endless chain (see Plate XIX., Fig. 1). The fan-fly revolves on the outside of the station wall, and between that and an outer wall erected to carry the carriage that holds the end of its shaft, which is in this instance 5·20 metres in length with three bearings, the fan is driven by bevel gear of 12 to 96. The speed of the train being one metre per second, the fan-fly makes 128 revolutions per minute. Four pairs of clams form arms to the blades and receive the deals ·03 thick of which they are composed, and readily admit of adjustment in the regulation of the governing power of the fan-fly.

To control the train there is also an ordinary lever brake with two adjusting screws on the brake-strap, which encircles a series of articulated segments of a circle formed in poplar wood; by this means the cleading or segments can be renewed without removing the brake-strap, or kept continually efficient by adding fresh cleats or segments in front of the wheel as required and taking out the worn ones from behind. The lever is balanced by a weight hanging from a pulley on the wall, heavy enough to slack off the brake. In applying the brake, to remove all possibility of any more sudden application than is necessary to stop the train in 20 seconds, and as a precaution against breakage of machinery or the

lifting of the chain out of the forks in the hollows, a slow-powered winch with hempen rope is used, which enables the brakesman to control the train at will.

Transport has formed a very important item in the costs of construction; the materials, after having been deposited at two or three points only accessible to bullock-carts carrying a load of half-a-ton and making (in dry weather) two journeys per day, were carried or dragged by the workmen to where they were needed. To avoid this, and the delay caused by bad or unfavourable weather, as well as to save cost, the masonry walls were dispensed with at A′, and instead, a wooden framework was erected (see Plate XIX., Figs. 7 and 8) consisting of two laced girders resting upon four light transverse beams. From the ends of these the guard, pulley, and carriage-beams, supported by the girders, were stayed; the latter beams are also laced, thus securing a lightness of structure combined with a rigidness favourable to their more general adoption under similar circumstances.

The 25 millimetre chain-wheels (see Plate XIX., Figs. 5 and 6) are formed of discs of 1·07 metre diameter, the top side being a flat plane at right angles with its axis, provided with a depending groove 145 millimetres deep and 80 millimetres thick; this groove contains 25 square sockets, whose centres only are radial to the centre of the disc, which receive the claws that are held out to the chain formed by a second or inner rim connected by partitions, dividing the sockets, to the outer rim, the whole designed to give free access to the tap bolts and to the brass washer liners used in setting the claws. The neck of each bolt is furnished with a spring washer (two dished washers placed with the concave sides together) as a protection against the unthreading of the bolts in drawing home the claws, which are planed on all sides that they may fit the sockets perfectly without vibration. The claws are designed to admit the horizontal links (which, when home, rest on the bottom of the notch prepared for their reception) and entering between, take hold of the after part of the vertical links. The most important point to watch in supervising the working of the wheels is to prevent the links from moving when once they have taken their form until they have to rise to leave the wheel; after the claw has once taken hold of the link it ought to remain at rest whilst in its form, as any movement means heavy wear and tear. To prevent this occurring the horizontal links are frequently tapped in the claws with a hammer; if they should sound as not in tension, then, as understood, the claws need putting out a little, which is done by slacking the top bolts of each alternate claw and inserting a millimetre (the thickness of the

thinnest) liner behind the claw. Should the setting out of the claws be overdone, the fore part of the vertical links will be immediately marked; then the claws must be set back by removing the liners. With such care as this, the wear and tear is reduced to a minimum that will compare favourably with that of any other description of wheel.

The 18 millimetre chain-wheels are (see Plate XIX., Figs. 2, 3, and 4) five-armed pulleys with a flat trod, in which is a groove cut to admit the horizontal links; in this fifteen claws are fixed, that take hold of each alternate vertical link; the claws terminate in bolts which, passing through the rim of the wheel, are held in their seats by check-nuts; they are further supported by notches in the flange that admit the sides of the claw.

Next in order of importance are the leading-off and leading-on pulleys, the design of which cannot have too much attention, especially if the chain should be as heavy as the one being described, for it is in passing over these, where bank-heads are short, that the chain under great tension is bent to a greater angle than elsewhere. To reduce this angle, a pulley of greater diameter is used; but as this mode of diminishing the friction materially affects the design of the whole structure, increasing the space occupied and requiring a more massive design than otherwise would have been necessary, a pulley (see Plate XIX., Figs. 9 and 10) was suggested as meeting requirements. It consists of two rollers with a sheave between them, all working freely and independently on a shaft furnished with loose brass collars, which, keeping the pulleys together and working free in the hanger, allow the same play of 19 millimetres that the chain has in passing through the opening A between the guides B. The diameter of the rollers and sheave are 276 and 209 millimetres respectively. The object of the sheave is to support the vertical link, whilst the space between the sides of the horizontal link is passing over the rollers, thus preventing the dropping of the chain $3\frac{1}{2}$ millimetres each time that a flat link passed over the pulley, or in other words, saving the chain 530 blows per minute, and much reducing the noise which is also of some importance.

The slots in the hanger afford the easy adjustment of the pulley to that height which will assure the horizontal links of the chain leaving the notches in the claws without friction. When the requisite height is ascertained, the hanger is prevented from working down by placing a piece of packing under the flange, or letting the flange into the top of the beam as the case may require.

The leading-on pulleys are best arranged when they hang independently of the guard bars, because there is always a difficulty in adjusting the guards when they carry the bearings for the pulley, so as to give it that freedom of play that leading-on pulleys, especially those in the bank-foots, require. The design (see Plate XVII., Figs. 7 and 8) shows a pulley composed of two reversible loose rollers and a sheave, working freely on a brass boss between two flanges, one of them being a removable screw flange which permits of the three pieces being taken apart and cleaned from the dirt that, carried by the chain, finds its way between the sheave and the rollers, and would, if not thus attended to, clog them; this pulley works also loose on a shaft held in the two eye-pieces riveted on to a plate provided with slots for the hangers.

The style of greaser preferred is a plain simple disc, or rather, pair of wooden discs, each well secured between a pair of flanged bosses on the same shaft or axle, the ends of which revolve in suitable bearings placed on the ends of the box containing the supply of grease, within which the discs revolve; it is either made of wood or cast in metal. On the periphery of the discs a strip of india rubber of 3 centimetres square is held by screws well let in, the whole so set that the axle of the tub in passing over compresses the rubber to the extent of 7½ millimetres, and whilst receiving a sufficient amount of lubrication for a journey of 5,000 metres, causes the discs to revolve and bring up a supply for the axle following.

Under the impression that the foregoing description of the railway would be considered incomplete without some reference being made to the cost of working it, or rather that a reliable estimate of the working cost would enhance the value of the paper considerably, an endeavour is made to furnish in detail such particulars as will explain in what manner the cost of leading per ton has been arrived at.

The value of the plant is taken, and as in the case of the chain and rails, a sum of money is reserved annually, which, at three per cent., will be sufficient to replace the first cost at the termination of eight years for the chain and fifteen for the rails; their value as old material being reserved to meet the cost of laying the new road, placing the chains, or for any contingency which at present it is impossible to foresee, but which after the lapse of so many years may occur.

The pulleys, rollers, cages, ropes, turntables, &c., are all included under the head of machinery, which is of substantial design, and an annual charge of seven per cent is made for depreciation and wear and tear, which is also supposed to cover any breakage the result of accident.

It is essential to the preservation of the wood-work of the bridges and framework at the stations, as also to the whole of the woodwork of the line that will admit of it, that it should be protected by a covering of paint or tar; the cost of this is included in the estimate for repairs to the woodwork, which also includes the renewal of the sleepers.

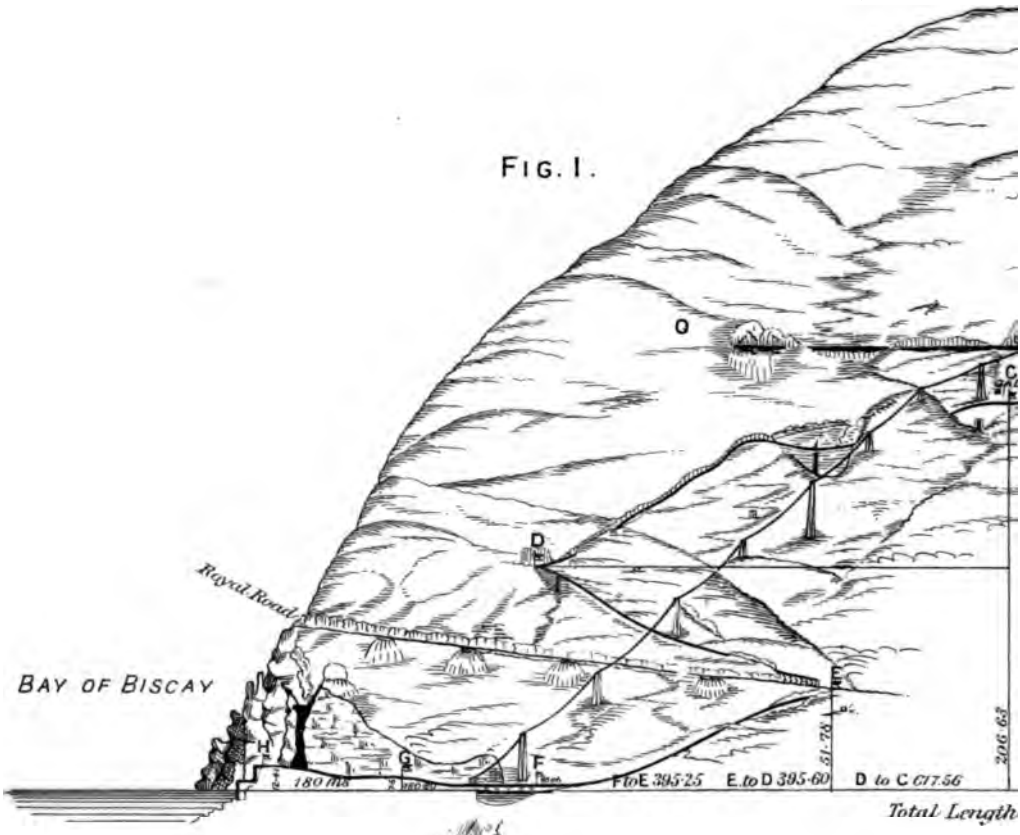
The cost of repairing the tubs can, necessarily, only be an estimate, but the figures given (·550 pence) are based upon a personal knowledge of the carefully ascertained cost of other tubs, and the contract price of such work is deemed sufficient to keep them in a high state of efficiency; this cost is necessary more to meet the wear and tear of the mine than that to which they are subjected on the railway. An important item in favour of the endless chain where there are heavy inclinations, is, that the destruction to rolling stock and plant through accident is less than that of other systems.

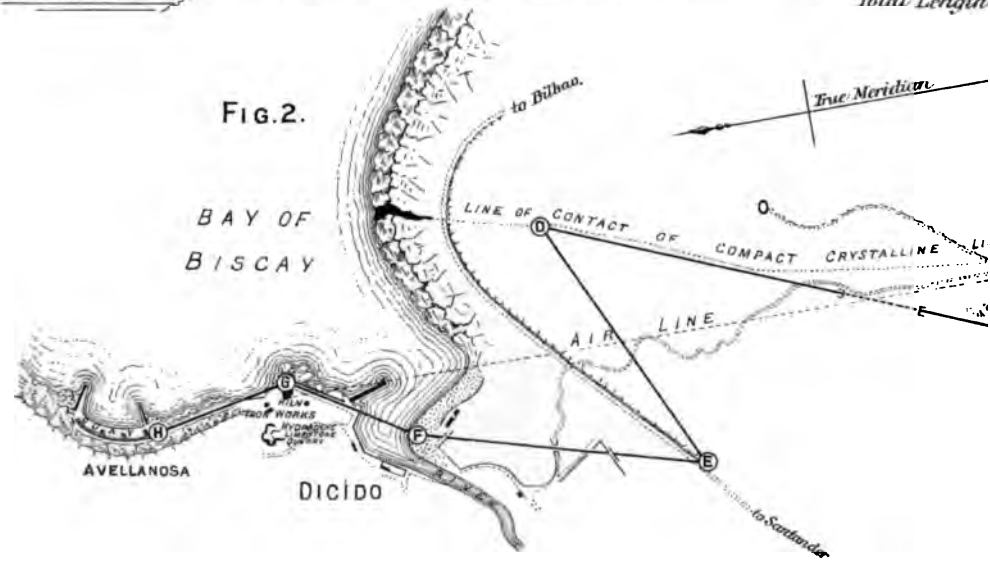
Under the head of stores the only charges are for oil, waste, lights, and a few little things, as all machinery, plant, and wood, to replace or to repair, together with all tools and stores used by the mechanics, are included in the wear and tear of machinery.

The cost of manning the line is heavier than it would otherwise have been, from the necessity for having the drop and the backshunts at D; the number of angles (not being stations) that need attention are two, F and G; the men placed at these angles are for the purpose of keeping a look-out over the unfenced lengths that pass through public grounds and thoroughfares, and for signalling.

In arriving at the cost per ton per mile, a fair average daily quantity is only taken. For instance, the speed at which the train travels is one metre per second, landing 180 tubs, or 90 tons of ore per hour. Limiting its working to 10½ hours per day, the quantity the chain would deliver in that time is 945 tons; but to meet the losses from bad weather, heat, accidents, and feast-days, 750 tons per day, or 225,000 per annum, is considered to be a quantity within the practical capabilities of the plant working under the present established regulations.

To illustrate Mr. George Lee's





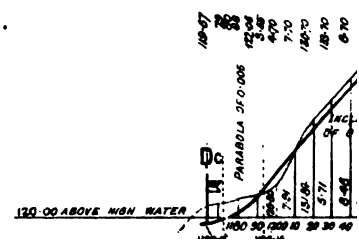
PLAN OF THE DICIDO WORKS.

Scale $\frac{1}{10000}$

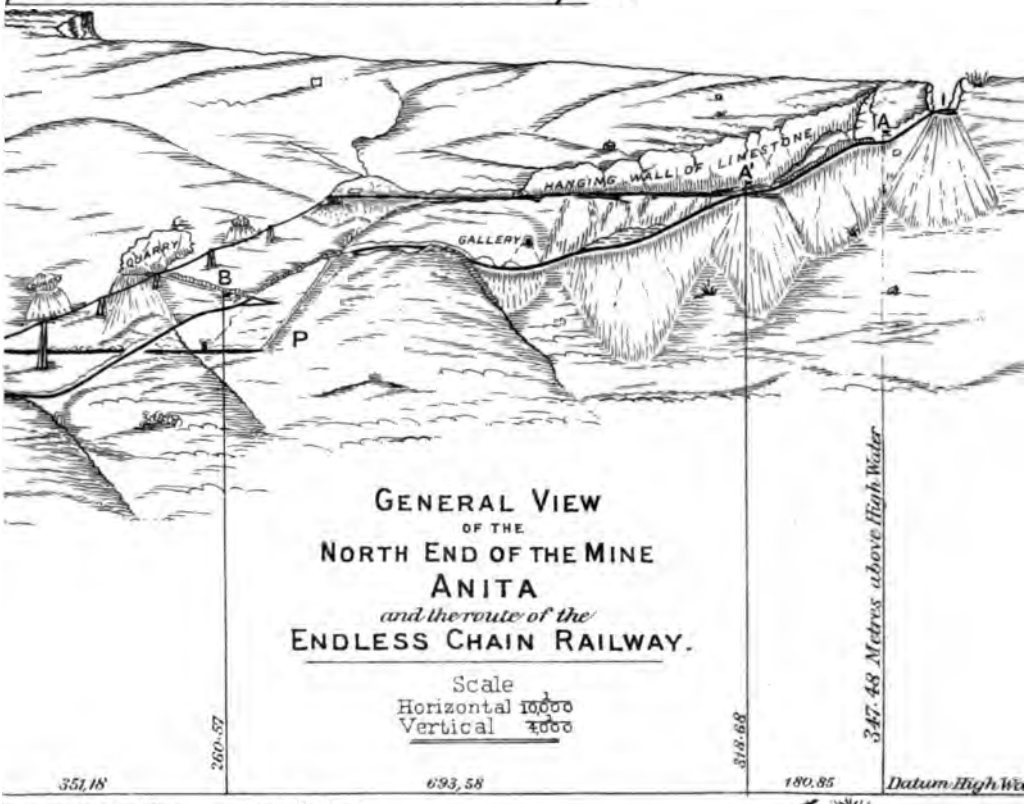
ALSO

SECTION OF LENGTH, C D.

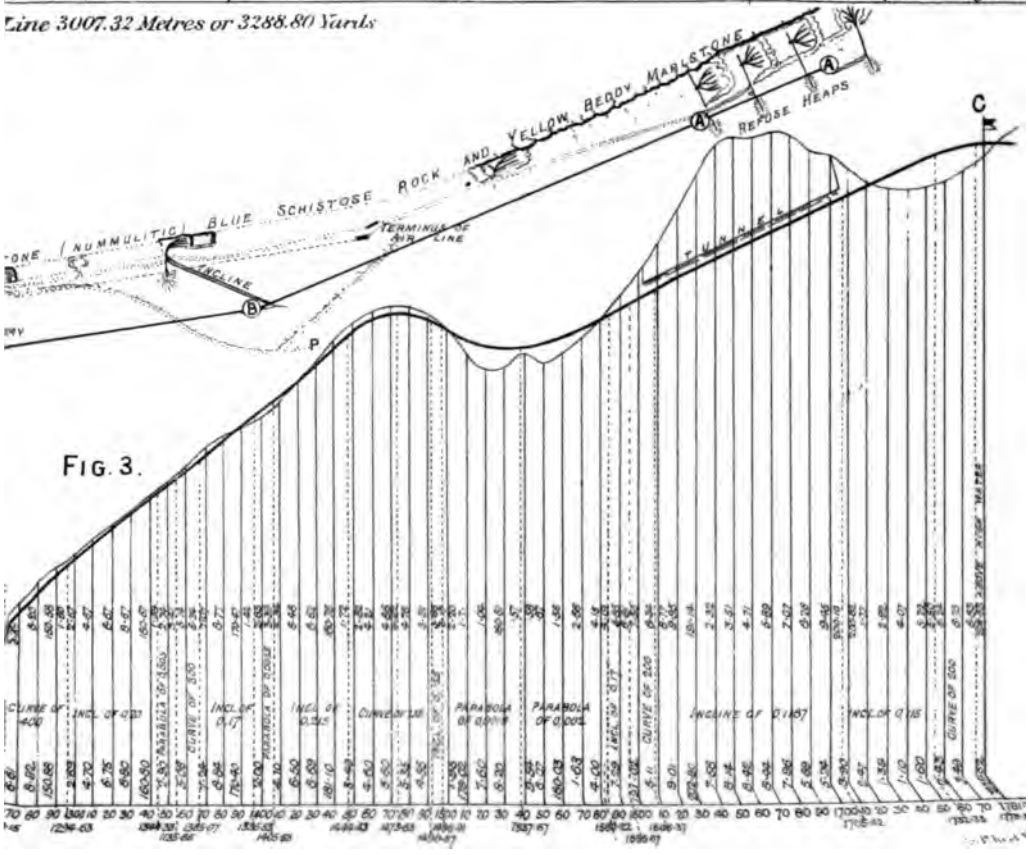
Scales, { Horizontal, $\frac{1}{4000}$ Vertical, $\frac{1}{1000}$



per "On the Endless Chain in Spain."



Line 3007.32 Metres or 3288.80 Yards



To illustrate Mr. George Lee's paper "On the Endless Chain in Spain."

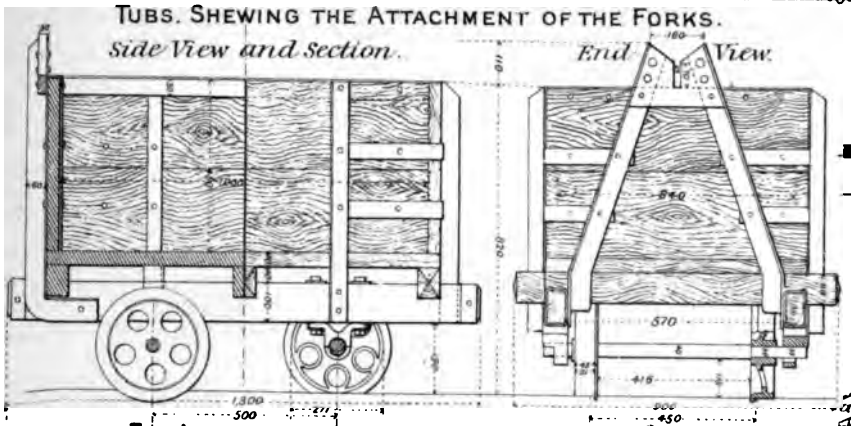


FIG. 1. Scale 1/20.

FIG. 2. Gauge

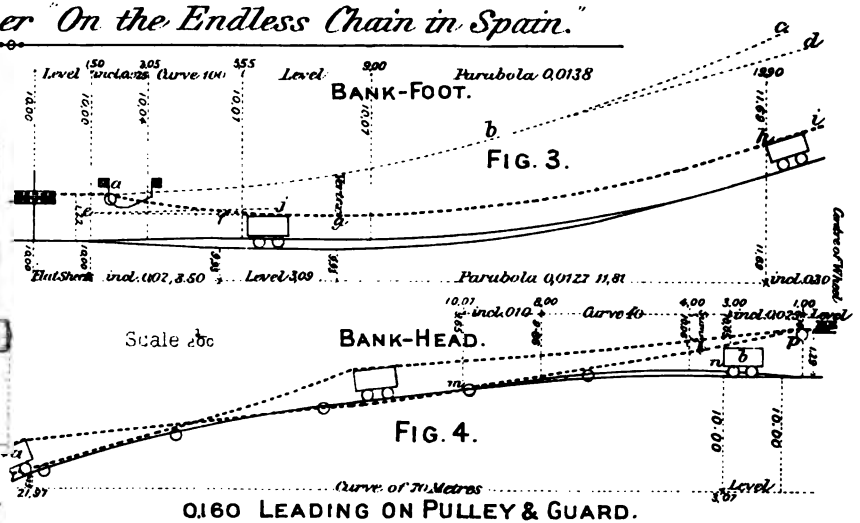
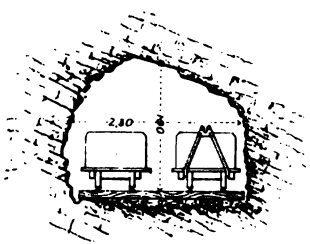


FIG. 3.

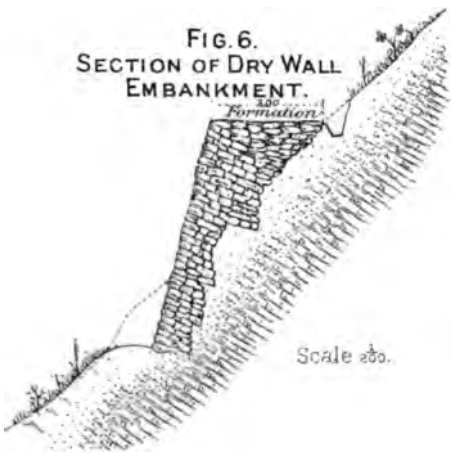
FIG. 4.

FIG. 5.
SECTION OF TUNNEL.



Scale 1/100.

FIG. 6.
SECTION OF DRY WALL EMBANKMENT.



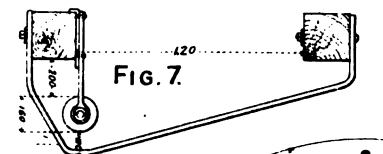


FIG. 7.

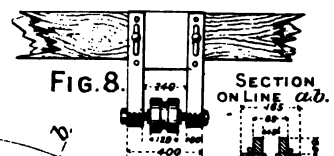


FIG. 8.

SECTION ON LINE a.b.

SECTION OF LOOSE WHEEL.

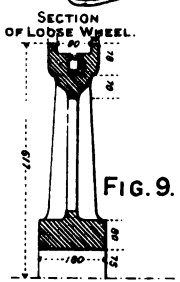


FIG. 9.

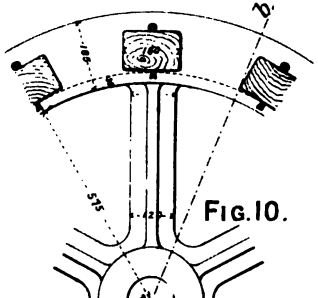


FIG. 10.

Balance Wheel

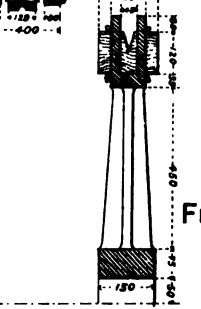
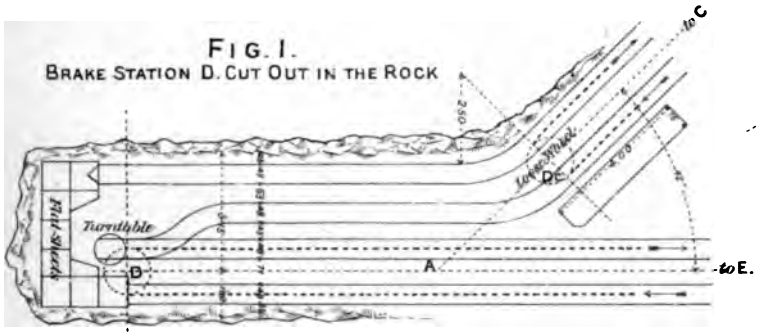


FIG. 11.

Proceedings No. E1 of M. & M. E. 1881-84

At Mr. Reid Newcastle

To illustrate Mr. George Lee's paper "On the Findless Chain in Spain".



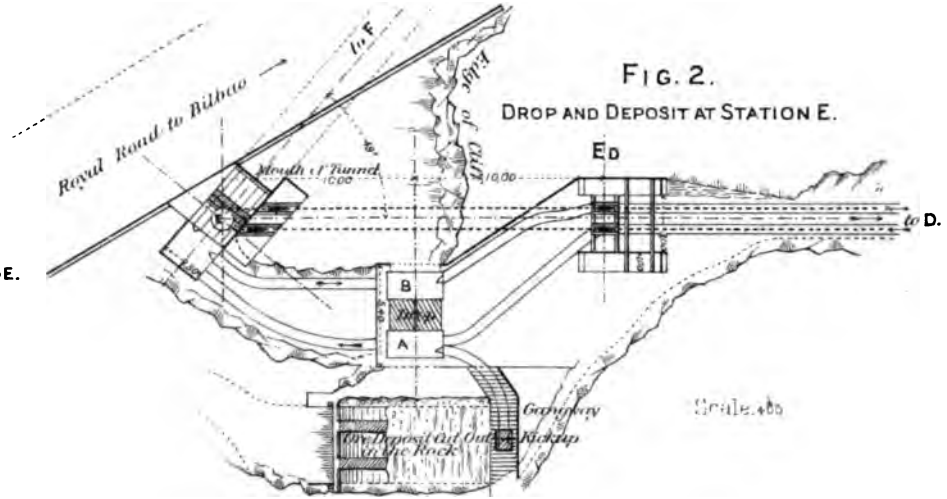
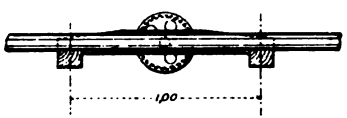
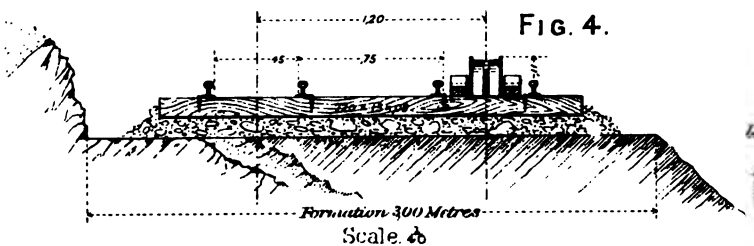
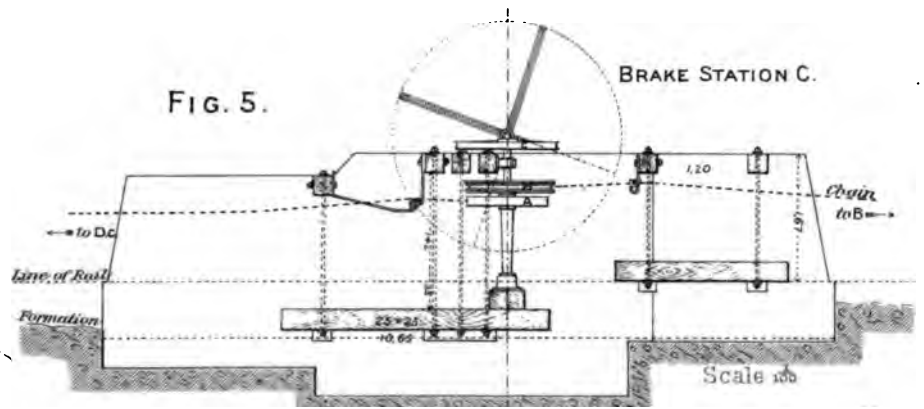


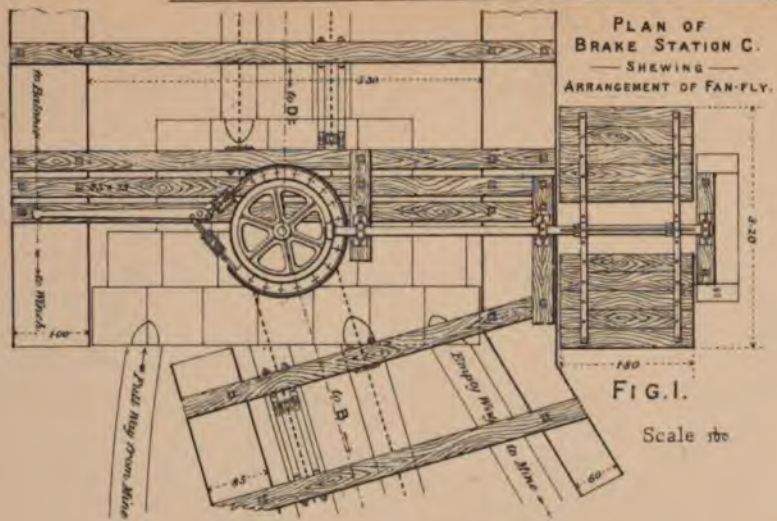
Fig. 3.
Transverse Section of Railway, and Method of Fixing Rollers.

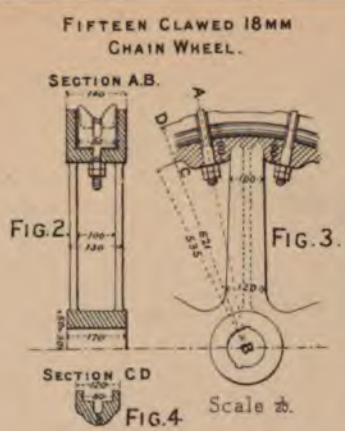


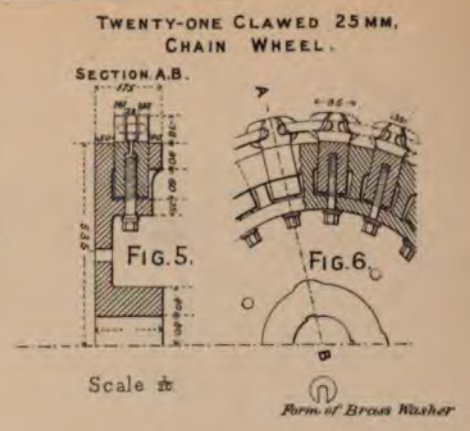


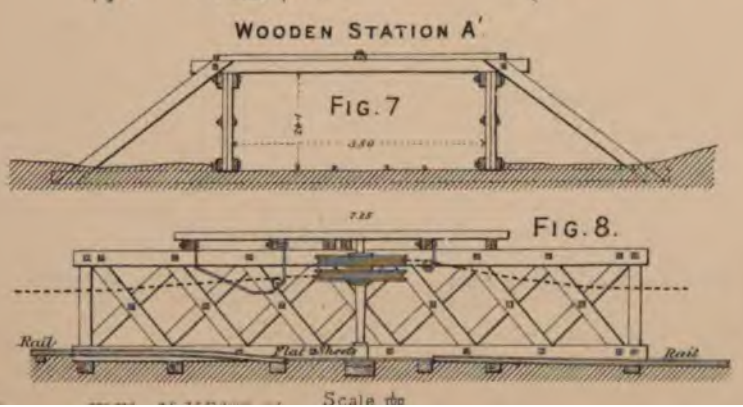


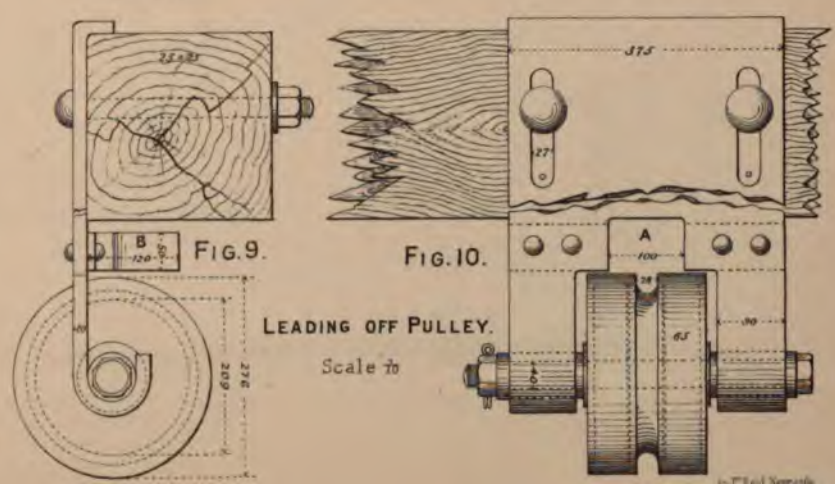
To illustrate Mr. George Lee's paper "On the Endless Chain in Spain."











COST OF WORKING.

	£		£
Value of chain ...	1,250	on a life of 8 years. Redemption	140·57
„ rails ...	1,525	„ 15 „ „	81·99
„ machinery	1,650	depreciation, wear and tear	115·50
Repairing wood-work, renewing sleepers, painting and tarring wood-work and machinery			42·50
			£380·56

	Pence per Ton.
£380·56 ÷ 225·000 tons	·406
Cost of repairing and keeping up the number of tubs in good working order	·550
Greasing	·070
Stores	·050

			Per Day. s. d.		s. d.			
Foreman	1	@	5 0	=	5 0			
Platelayers	4	„	2 4	=	9 4			
Fitter	1	„	4 0	=	4 0			
Labourers	2	„	2 4	=	4 8			
					——	23 0	=	·368

Wage.	Hangers on. s. d.	Brakesmen. s. d.	Tender. s. d.		s. d.			
A ...	2 4 ...	— ...	— ...	— ...	=	4 8			
A′ ...	2 ...	— ...	— ...	— ...	=	4 8			
B ...	1 ...	1 ...	1 ...	— ...	=	6 7			
C ...	1 ...	1 ...	1 ...	— ...	=	6 7			
D_C ...	— ...	1 ...	— ...	— ...	=	1 3			
D ...	2 ...	1 ...	1 ...	— ...	=	8 11			
E_D ...	— ...	1 ...	— ...	— ...	=	1 3			
E ...	1 ...	1 ...	— ...	— ...	=	3 7			
F ...	— ...	— ...	— ...	1 ...	=	1 3			
G ...	— ...	— ...	— ...	1 ...	=	1 3			
H ...	1 ...	— ...	— ...	— ...	=	2 4			
						——	42 4	=	·677
DROP.									
Top	2 ...	1 ...	1 ...	— ...	=	8 11			
Bottom	2 ...	1 ...	— ...	— ...	=	5 11			
						——	14 10	=	·237
Total cost per ton									2·358

Then $2{\cdot}358 \div \frac{3288{\cdot}8}{1760} = 1{\cdot}261$ pence per ton per mile.

The PRESIDENT said the writer of the paper was not present. It contained a description of the endless chain system in Spain where the system appeared to have been carried out successfully. One could not see that there was any great novelty in it; it appeared to be the same on a larger scale as that in operation in this country, but it was interesting to observe how the system was carried out in various districts, and more especially how the cost was affected by the circumstances of different localities. He moved that the discussion of the paper be adjourned.

Mr. T. J. BEWICK seconded the motion, which was unanimously agreed to.

The following paper, by Mr. B. J. Forrest, on "The Bilbao Iron Ore Mining District," was taken as read, and will be open for discussion after the paper is issued to the members:—

THE BILBAO IRON ORE DISTRICT.

By B. J. FORREST.

GEOLOGICAL AND GENERAL DESCRIPTION.

The centre or focus of these mines is situated on the Cantabrian or north coast of Spain, eight miles north-west of Bilbao, and two and a half miles from the village of Somorrostro. Their general form is that of an ellipse, two and a half to three miles long by one mile wide, and ranging from 600 to 1,000 feet above sea-level. The general bearing of the lodes is N. 30° to 32° W.; there are also flyers from the main lodes towards Onton and Castro in a north-west direction, and to Alonsotegui and Ollargan in a south-east direction; Galdames and Sopuerta to the west may be taken as separate deposits. The mining district (see Plate XX.) is divided into six groups, viz.:—

1.—Triano and Somorrostro.
2.—Galdames.
3.—Sopuerta and Montellano.
4.—El Regato.
5.—Abando.
6.—Ollargan.

The foregoing groups cover about 16,000 acres of land, and are estimated to contain 160,000,000 tons of iron ore; but the author is of opinion that 55,000,000 tons would be a fair quantity, after allowing for faults, loss, and débris.

The stratification generally, in the Triano district, consists of greyish blue limestones, reposing on and mixed in some places with micaceous rocks or greywacké, and in others with schistose grit.

In the valleys or erosions are found bluish marly limestones (decomposed in some places) and calcareous clays, and alluvial deposits generally in river estuaries. The limestone and grit usually form bed and walls to the ore and in some cases cut it out. (See Plate XXI., and Plate XXII., Figs. 5 and 6.)

The ores met with in Triano Mountain are the following, viz.:—

Vena and campanil: red hæmatite (anhydrous ferric oxide).
Rubio: brown hæmatite (hydrated ferric oxide).
Carbonato de hierro: spathic ore or siderite (ferrous carbonate).

The ore varies from 100 to 250 feet in thickness, and in some of the best mines is covered by five or six yards of limestone.

In the lower part of the formation or deposit of vena and campanil, cavities are found coated with specular iron ore in crystals and stalactites, the latter being usually found in caves which are generally eroded or separated by clay when found in the rubio formations.

These ores are generally supposed to have been deposited by hot springs well charged with carbonate of iron which has filled up all basins, cracks, or fissures adjacent to them. Taking this hypothesis to be correct, the vena and campanil were deposited first at a high temperature, and the rubio later at a lower temperature. The mass generally increases from the sides to the centre.

Two large erosions are seen in the valleys of Granada and Pacheta, but the lodes continue in the same direction, forming on the south end the large Orconera and Matamoros deposits, and on the north end the Las Carreras and San Lorenzo lodes.

The ores may be classified as follows, viz. :—

Vena, dura and dulce.—This is the richest of all the ores and the only kind worked by the old miners for the Catalan forges; but as it is soft it crumbles up to powder directly, and *glags* (shoots) in wet weather.

Campanil.—This is a species of red hæmatite, and resembles some of the Asturian iron ores in texture, etc. Where the decomposition has not been complete, it is distinguished by a greater proportion of carbonate of iron, which gives it more durability.

The quality of the ore is good, but it cannot be considered as manganiferous. Sulphur and phosphorus are found in small quantities. It is not usual to calcine campanil ores. The colour of campanil is red, inclined to violet. It contains in the dry state from 50 to 60 per cent. of metallic iron. It is found towards the centre of large masses and often in contact with limestone and grit. It improves in quality as depth increases. Bands of hæmatite and siderite are sometimes seen mixed together; in the San Miguel and Begoña mines this has been observed in the form of broad bands, called by quarrymen pedrisco. As campanil is generally purer and harder than the rest, it is the most esteemed.

The specific gravities of these ores are as follows: campanil from 2·6 to 3, and rubio from 2·3 to 2·6. One cubic metre of campanil weighs nearly two tons (30 cwt. per cubic yard), and one cubic metre of rubio about 36 cwt (28 cwt. per cubic yard).

THE FOLLOWING IS A STATEMENT OF THE ANALYSES OF THE VARIOUS ORES.

Elements.	Classes of Ore.										
	Vena.		Campanil.		Rubio.		Siderite.	Campanil arenado. (Campanil and Vena mixed.)		Rubio arenado. (Rubio and Vena mixed.)	
Water (combined) ...	5·00	5·00	5·65	6·00	8·84	8·55	24·20	4·40	7.15	7·55	12·45
Carbonic acid... ...	0·40	0·40	5·00			3·00	1·90	1·20	0·85	0·65	
Insoluble residue ...	1·20	1·20	6·60	3·20	13·76	7·22	7·00	1·00	2·50	3·50	3·95
Alumina	1·20	...	1·90	...	2·26	2·18	...	...	...	...	...
Lime	1·00	0·50	4·50	4·60	0·32	0·30	2·10	1·40	1·00	0·71	traces
Magnesia	0·20	0·10	1·25	...	traces	traces	0·15	...	0·40	...	...
Oxide of manganese ...	1·30	0·70	1·96	1·90	traces	0·03	0·80	1·00	1·10	1·00	0·68
Ferrous oxide ...	...	...	traces	...	...	0·03	46·10	...	...	...	...
Ferric oxide	90·70	91·70	74·20	84·00	74·70	78·35	17·64	91·05	86·20	85·30	82·64
Sulphur	0·035	0·075	0·02	...	0·006	0·02	0·165	0·045	0·017	0·035	traces
Phosphorus	...	0·02	0·01	traces	0·08	0·03	...	0·015	0·025	0·015	traces
Metallic iron	63·50	64·20	52·0	58·80	52·29	54·84	48·20	63·75	60·35	59·75	57·85
Manganese	1·05	0·50	1·40	1·30	traces	0·02	·60	·71	·80	·72	·49
Total Metal ...	64·55	64·70	53·40	60·10	52·29	54·86	48·80	64·46	61·35	60·47	58·34
Insoluble residues—											
Silica	1·05	1·20	6·60	3·20	13·76	7·22	5·95	1·00	2·20	2·55	2·90
Alumina	0·15	...	1·90	...	2·26	2·18	1·05	...	0·30	0·95	1 05

Rubio generally forms the upper portion of these formations, and usually stands out in boulders and peaks (see Plate XXIII.), looking very imposing; but it is often full of large cavities and caverns, filled with earth and clay. The ore has generally a honeycombed appearance and structure.

It requires much more classification and cleaning than campanil or vena, on account of impurities found mixed with it in the form of silicious earth.

Carbonato de hierro (spathose carbonate of iron).—This is found in blocks and bands, and near outcrops and erosions. It merges into pedrisco and limestone. A very strong band of this ore and pedrisco (to which reference has already been made) was driven through in the San Miguel mine. A large quantity of this ore is met with in Concha, No. 7 mine. It gives about 43 per cent. of metallic iron. No phosphorus is found in siderite or spathic ores. The sulphur and other volatile substances, together with the carbonic acid and water, are given off when spathic ores are calcined. The Franco-Belga Company made trials and intend to calcine this ore.

LIST OF SOME OF THE MOST IMPORTANT MINES.

C.—Campanil. V.—Vena. R.—Rubio.

NAME.	CLASS OF ORE.	NAME.	CLASS OF ORE.
Begoña	C.	Lorenza	V., R., and C.
Cesár	C. and V.	Petronila	V. and R.
Ser	C. and V., (nearly worked out).	Diana	C. and V., (nearly worked out).
Catalina	C. and V., (partly worked).	Despreciado	V. and C.
Orconera	V. and R.	Perseguida	V. and C.
Nicanora	C. and V.	Justa	V.
Olvido	C. and V.	Marquesa	V. and C.
Indiana	C. and V.	Pacifica	V. and R., (nearly worked out).
Esperanza	C. and V.	Rubia	R.
San Antonio	C. and V.	Socorro	V. and C., (nearly worked out).
San Ignacio	C. and V.	Sol	V.
Cristina	V. and C.	Vigilante	V.
San Benito	V. and C.	Trinidad	V. and R.
San Martin	V. and C.	San Fermin	V. and R.
Barga	V.	Aurora	V. and C.
Buena Ventura	V.	Alondiga	V., C., and R.
San Severino	V. and C.	San José	V. and R.
Buena Estrella	V. and C.	Eléna	R. and V.
Altura	V. and C.	Adela	R. and V.
Concha	R. and V.	Julia	R. and V.
Confianza	R., V., and C.		

The most important mineral zones in Triano Mountain are the following :—

1.—Triano mines proper, taking a radius of 600 metres from the south west corner of Cesár mine.

2.—The Orconera and Matamoros district.

3.—The Concha and Cadegal district.

4.—A rectangle from Catalina mine to the Lorenzo and Isabela mines, Las Carreras district.

5.—The author is of opinion that a fair quantity of rich campanil exists under the limestone in the Elvira and adjacent mines (Galdames range), and would be worth investigation.

6.—El Regato district.

7.—Montellano and Sopuerta.

SYSTEMS AND COST OF QUARRYING.

The mines are invariably worked open-cast or in quarries. The plan of working in the best appointed mines is to remove a zone of débris and then one of ore; but this plan is not generally adopted, as in most cases each mine has a different owner, an imaginary line between two boundary stones being the only boundary between them. Quarries become choked up by their own débris (see Plate XXI.), with the exception of those mines that have a deep valley or sufficient space to tip their refuse; when the latter is not the case the working becomes very costly, and mine-owners are always at law with each other.

Some of the larger quarries are worked in two or three lifts of from twelve to fourteen yards high. The base of ore is attacked by driving a tunnel or gallery underneath the floor of the mine, and wagons can thus be loaded direct from the faces. A good example of this system can be seen in the Cesár mine.

Large blasts are not common, although occasionally large shots are fired. The vena has been worked for many years by tortuous galleries, and in a few places by winze holes and old-fashioned jack-rolls. The vena (or vein, as its name indicates) was got by short miners' picks. It was then put in baskets or panniers and carried out by boys or donkeys. Some of these galleries run for a great distance underground without any regard to ventilation. The ore was commonly treated in forges worked by water-wheels or turbines. The campanil and rubio are harder than vena, and will stand transport or manipulation better. Rubio is harder than campanil, but requires more cleaning and classifying to get rid of the impurities (silicious earths) mixed with it.

The work is generally let to small contractors (who are not a very intelligent class of men as a rule); they find labour, powder, fuse, and tools, the company or mine-owner supplying plant, wagons, etc.

The Biscayan quarryman compares favourably with the general run of this class of men in Spain, being strong and active, and excels in the use of the jumper; but his notions as to the placing of the shot-holes are vague, and scorching is a common occurrence.

The tools generally used are the jumper or large drill, also crowbars for disengaging rock blown down; but preferably they use the jumper for all purposes. A good quarryman will drill about one foot in twenty minutes (including stemming and drying) in campanil, and three-quarters of a foot in rubio or limestone in the same time. The best class of ore-breaker is a narrow-headed, wedge-shaped steel hammer, very useful in the hands of a skilled labourer. The drills, or jumpers, weigh on an average 25 to 30 lbs., and some of the larger ones, requiring six or eight men to handle, weigh from 150 to 200 lbs. each, and are nearly 30 feet long. The crowbars weigh about 50 lbs. each. Multiple wedges are used in some quarries, and for other classes of labour, rakes, hoes, and baskets are used. A good quarryman can get about five tons of ore per day of ten hours in a well-appointed quarry.

The average rate of wages paid are :—

Drillers ...	...	...	from 2s. 6d. to 3s. 0d. per day.
Loaders ...	...	...	„ 2s. 0d. to 2s. 6d. „
Ordinary labourers	...		„ 1s. 6d. to 2s. 0d. „
Women and lads	...		„ 1s. 0d. to 1s. 6d. „

The hours of work are usually from sunrise to sunset, with half an hour for breakfast, two hours for dinner in summer and one in winter, and a quarter to half an hour for afternoon *snap* in summer. Drillers are sometimes paid at so much per foot drilled (from 1d. to 3d. per foot), and loaders, when working long hours or in relief gangs, at so much per hour.

Compressed air or hydraulic machine-drills or cutters are unknown, but could be used to advantage in driving tunnels or galleries or straight work. Novelties of this description are looked upon with jealousy and disfavour by the quarrymen and miners.

The explosives generally used are powder and dynamite, the latter well mixed with the former. Dynamite is generally used in rubio mines to enlarge the base of shot-holes for filling with powder. The usual plan is :—After a hole is drilled, a small cartridge of dynamite is

inserted and fired; this forms a cavity or pocket in the bottom of the shot-hole, and also cleans it out ready for charging with powder. Dynamite is also commonly used to break loose rock. A hole a few inches deep is drilled on the top-side of the rock, and a cartridge is inserted and fired. It requires about one pound and a half of powder to displace one ton of ore.

The prices of explosives vary, but are :—

Dynamite	about	£2 10s. 0d. per case of 25 kilogs. (55 pounds).
Powder	„	3½ reals per kilog. (4d. per pound).
Fuse	„	20 reals per roll. (4s. 2d.)
Capsules	„	16 reals per 100. (3¼d.)
Compressed powder	„	7½ reals per kilog. (8¼d. per pound.)

The average cost of getting, etc., varies from 1s. to 2s. 5d. per ton: the last figure being sometimes reached in rubio mines. The first-named figure would apply to campanil mines, and might be divided as follows, viz.:—

Labour, about	7¾d.	per ton.
Powder, fuse, tools, and plant ...	4¼d.	„
Total	1s.	„

The contractors' profit ranges from 10 to 20 per cent., and he generally makes something extra out of the men he employs by their keep. This has its good and bad effects in controlling the men.

The workman's cottage system is not in vogue here.

Large gangs of men are employed by some of the most important companies in loading trains. This is commonly done by baskets, but in some cases it is loaded direct. The author is of opinion that some thousands of foot-tons of power are lost weekly by allowing all the larger streams of water to run to waste, as there is a great head of water in many instances, and hydraulic machinery and accumulators might be profitably employed for many purposes.

TRANSPORT AND HAULAGE OF ORE.

There are various systems in vogue, viz.:—

Mules and donkeys with panniers.
Bullock carts.
Wire tramways (aerial).
Inclined planes.
Endless chain.
Endless rope.
And in some cases for a short distance, shoots.

PANNIERS.

The mule and donkey system pays best in poor and awkwardly-situated quarries. The ore is carried in panniers holding about one cwt. each.

CARTING.

A large number of men are employed in this work. The system has its advantages and disadvantages, according to the situation of the mine or quarry and its approaches. The plan is to yoke two powerful bullocks to a cart 8 feet long, 3¼ feet wide, 1 foot deep, and carrying from one-and-a-half to two tons of ore. The wheels are about 3 feet 6 inches diameter, and the tyres 3 inches broad, which cut up the roads fearfully in wet weather. The axles are sometimes made of wood about 9 inches diameter. Up to within a few months an average of nearly 2,800 tons of ore has been tipped by carts alone into the Deputation Company's deposits at Ortuella. The rates charged give an average of about four reals per ton per kilometre (1s. 4d. per ton, per mile). This is a favourite method of transport with mine-owners who do not care to lay out much capital on other systems of haulage.

WIRE TRAMWAYS (AERIAL).

There are two systems in vogue, viz., Hodgson's and Bleichart's (Leipsic). The first-named and most generally used consists of an endless wire rope, carried over small pulleys secured to trestles and round large terminal pulleys from and through which movement is imparted to the rope, upon which is suspended by a hanger and box-head, a bucket holding about two and a half cwt. of ore. (See Plate XXIV.)

The Bleichart system consists of two endless ropes carried over trestles, similar to Hodgson's, but with the following differences, viz.:—The upper rope is fixed, and is practically a rail for box-heads to run upon. The lower rope is much thinner and acts as a traction rope; by means of patent clips the bucket-hangers are made fast to the latter, which impart the movement to the buckets carrying about three cwt. of ore. (See Plate XXV.)

Hodgson's system is more generally adopted for moderately easy gradients, and where first costs must be light. The gradient in this system must not be more than 1 in 4, or the box-heads will slip in wet weather.

Bleichart's system is preferable for steep gradients, as the clip prevents the box-heads slipping, so that it could be made self-acting. There are about twenty miles of Hodgson's system working, and about two miles of Bleichart's. The cost of transport would be about 5d. and 6d. per ton per kilometre (8d. and 10d. per ton per mile), respectively on a fair average gradient. The wear and tear is extra, and varies considerably on different tramways and between the two systems. The wear and tear of the rail-rope in Bleichart's system is heavy. The motor in Bleichart's tramways in one case, is gravity; in another of Hodgson's a portable engine of 25 horse-power. Both are governed by powerful brakes. The life of the wire ropes varies greatly according to contour of line and manufacture, and ranges from 100,000 to 200,000 tons carried, and in some cases to double this quantity. The average number of days worked per annum is 286.

An approximate cost of the erection of each system would be as follows, viz.:—Hodgson's, for single and double lines, from £1,200 to £2,500 per kilometre (£2,000 to £4,000 per mile), according to contour of ground. Bleichart's, single line, from £2,000 to £4,000 per kilometre (£3,200 to £6,400 per mile).

The ropes are steel wire, with seven wires per strand, and six strands in each rope, with cores of tarred hemp. Trestles from 3 to 170 feet high. The span between trestles varies from 10 to 120 yards, the average being about 40 yards.

The systems may be thus compared :—

Hodgson's :—1.—Cheaper erection.
2.—Less wear and tear of ropes.
3.—More than one line can be fixed on each trestle.
4.—Gradients must not exceed 1 in 4.

Bleichart's:—1.—More costly erection.
2.—Heavy wear and tear of ropes.
3.—Only one line can be fixed per trestle.
4.—Works well at any gradient, and self-acting when exceeding 1 in 4.

Name and Data for Each Line of Wire Tramway.	Hodgson's.						Blei-chart.	Otto.
	San Miguel Mine to Ortuella.	Arnistad Mine to Deputation Railway.	Union Mine to Deputation Railway.	Parcocha Mine to Galindo River.	Marquesa Mine to Ortuella.	Primitiva Mine to Zorroza.	Aurora and Buena Estrella Mines to Ortuella Station.	Julia and Adela Mines to Inclined Plane.
When inaugurated (year) ...	1878	1872	1874	1879	1881	1881	1878	1882
Number of lines working ...	3	3	3	3	1	1	1	1
Length of tramway, in yards	1,311	3,188	2,974	2,773	1,880	3,169	2,019	566
Difference of level of extremities, in feet	348	1,401	1,443	1,103	722	341	774	154
Diameter of ropes, in inches	·906	·985	·985	·985	·985	·906	1·45 & ·788*	·906
Distance between trestles, in yards	44	48	48	55	33	49	27	49
Distance between buckets, in yards	33	33	33	29	33	49	45	33
Velocity of buckets per hour, in yards	5,232	6,976	6,976	6,867	4,372	6,558	5,886	6,558
Weight carried by buckets, in lbs.	353	441	441	397	441	330	550	441
Horse-power of driving engine	20	20	20	16	18	25	Gravity.	
Mineral that can be carried daily, in tons	700	600	600	600	300	150	360	600
Average carried per annum...	147,000	125,000 each		140,000	72,000	(stopped)	112,000	new.
Men employed	74	70	70	72	26	12	32	16
Cost of transport per ton per mile, in pence	12·5	11·45	11·25	12·0	12·5	13·75	10·5	10·75
Cost of tramway (complete), in pounds... ... about	£6,000	£30,000		£18,000	£11,000	£12,000	£11,200	£2,400

* Rail rope 1·45 inches, and traction rope ·788 inches diameter. A real = 2½ pence.

INCLINED PLANES.

There are eight inclined planes working, and an engine plane on to the Bilbao Iron Ore Company's Railway at Pacheta.

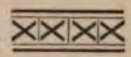
Orconera Incline.—The most important is the Orconera Iron Ore Company's incline to their Orconera and Matamoros mines. It is 1,199 yards long; average gradient about 17 per cent.; two roads, 3 feet 3⅜ inches gauge; rails 56 lbs. per yard; overhead drums, 15 feet diameter; load, 5 wagons of 34 tons in all. An ingenious contrivance is to be seen at the top of the incline in a disengaging arm, acting on a lever placed in front of the wagons; this disengages the rope-shackle and allows the train to run away into the mines.

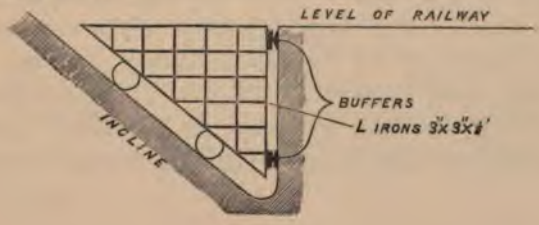
The discharging arrangements at the bottom of the incline are well planned, gravity doing nearly all the work. The full and empty trains run to and from their appointed places alone. The discharging from incline

wagons into main line wagons is done by counter-balanced tipping cradles, controlled by foot-brakes. About 1,500 tons are transported over this incline daily (10 hours). There are two or three curves of from 600 to 1,600 feet radius, round which the rope is conducted by side roller pulleys. Further data referring to this and other inclines will be found in the summarised statement given on page 225.

The Concha or Franco-Belga Company's Incline.—The main incline is 509 yards long; double roads, 3 feet $3\frac{3}{8}$ inches gauge; overhead coned drums, 16 feet diameter; total fall 184 yards or about 31 per cent.; steel rails, 48 lbs. per yard, carrying about 800 tons daily. A large four-bladed fan brake is connected to the drum shaft by spur wheel and pinion, which arrangement considerably reduces the momentum of the load, and can be graduated by lengthening or shortening the sails; the total width of the sails is 6 feet, and diameter over the arms 16 feet. This incline is connected by two lines with an upper incline 207 yards long; gradient, 1 in 2 nearly, and will carry 200 to 250 tons daily. This was formerly worked with one of Fowler's clip-pulleys, which was found to be unsuitable for the class of rope used and work to be done.

Justa Incline.—This is adjacent to San Fermin Incline, and connected with a deposit at 6·5 miles on the Galdames Railway. It is 253 yards long; double roads, 2 feet $7\frac{1}{8}$ inches gauge; rails, 30 lbs. per yard. The rope runs through two pulleys 9·8 feet diameter, but in this case the roads do not run underneath the machinery. The wagons carry about 4 tons each, and are strongly made. The rope is $1\frac{3}{8}$ inches diameter; the last one taken off carried about 200,000 tons. Carrying capabilities of incline, 300 tons daily.

The San Fermin Incline from Trinidad mine to 6·5 miles on the Galdames Railway is a well laid down incline, but very steep, being nearly 1 in 1; double roads, 4 feet $9\frac{1}{2}$ inches gauge; rails, 56lbs. per yard, laid on longitudinal balks about 1 foot wide and 6 inches thick, kept in place by diagonal braces and tie rods, thus  gussets and packing pieces are bolted to the bottom side of and through the joints of the longitudinals, and then let into steps cut in rock or set in concrete. The railway trucks are run on to a triangular-shaped carriage, thus:—



The rails have joints 2 feet from either end; a ratchet in the form of a sector is riveted to the bottom of the rail; when the end is raised, a small weighted catch keeps it in its place, and the wagon is prevented from running off the carriage. This incline is capable of carrying 1,000 tons per day.

Rubia Engine Plane.—This is situate on the Galdames Railway, and is 180 yards long with double roads. Inclination, 1 in $2\frac{1}{2}$, nearly; diameter of rope, 1 inch; tons carried daily, from 200 to 250; gauge about 1 foot 6 inches; rails about 18 lbs. per yard; load, one or two small side-tip wagons, carrying about $1\frac{1}{2}$ tons; these are drawn up by one of Stevens's double-cylinder winding engines; the tubs pass under the engine and on to the deposit.

La Salve Incline.—This incline is worked in conjunction with the Alonsos narrow gauge railway. It consists of two roads, 4·92 feet gauge; rails, 35 lbs. per yard; flat rope, 3 × ·47 inches, with 120 wires. The load consists of two large trap-door hoppers, which are filled by branch-line wagons at top, and are discharged through a shoot into small tip-wagons at the foot of the incline. Load, 5 tons; diameter of overhead drum, 6 feet 3 inches; the brake-straps act on a projecting collar on the drum which is 11 feet 6 inches diameter. The faces of the brake-straps are kept moist by a spray of water forced from a ram, worked by an eccentric from the drum-shaft. This also assists the brake and forces water into an adjacent tank. Carrying capabilities, 500 tons daily. In continuation of this is a small incline worked by a differential or compensating drum, which serves full and empty roads to and from the deposit, one of which is longer than the other and at a different gradient, thus:—

Julia and Adela Inclined Plane.—This plane works in conjunction with a wire tramway from Julia and Adela mines, and terminates in the Ortuella Station of the Deputation Railway Company. Length, 436 yards; two roads, gauge 2 feet 8 inches. Belgian-made wire rope, 1·57 inches thick (too thick and heavy for the work). The arrangement of machinery is taken from the Bodovalle Incline. This incline is

defective in not having a greater distance from brow-top to pulleys, thus limiting the number of wagons per train. Diameter of pulleys, 9·84 feet; gradient of incline to deposits, 1 in $4\frac{1}{2}$.

Bodovalle Inclined Plane.—This incline is situate between the San Miguel and Begoña mines and the Bodovalle Station on the Galdames Railway. It belonged formerly to the Bilbao Iron Ore Company, for whom the author got up plans arranged so that the wagons ran over the top of the pulleys and not under them. Diameter of pulleys, 6 feet 3 inches; gauge of roads, 2 feet 8 inches; rope, 1 inch diameter; gradient, 1 in $5\frac{1}{2}$.

Observations.	Names of Inclined Planes.							
	Orconera.	Concha, No. 1.	Concha, No. 2.	Justa.	San Fermin.	Rubia.	La Salve.	Julia.
When opened (year) ...	1880	1881	1881	1879	1881	1881	1881	1882
Total length, in yards...	1,199	508	207	253	180	181	261	437
Average gradient ...	17 %	31 %	49 %	51 %	80 %	39 %	33 %	32 %
Diameter of wire rope in inches	1·45	1·49	1·65	1·57	1·77	1·0	3 × 47	1·57
Men employed	37	28	11	13	9	8	7	10
Daily transport in tons	1,500	800	250	300	400	235	500	400
Maximum do. do. ...	2,620	1,500	1,000	500	1,000	...	600	...
Approximate cost of transport per ton ...	4d.	3d.	3d.	3d.	3d.	3d.	$3\frac{1}{2}$d.	$3\frac{1}{2}$d.
Total cost of incline ...	£46,000	£15,200	£8,500	£3,000	£5,000	£2,500	£6,500	£3,650

ENDLESS CHAIN.

This system is being worked by the Franco-Belga Company in their Concha mines with good results. It extends from the top of the upper incline to the San Martin mine, and the general arrangements are similar to those commonly seen in or about English collieries and iron mines, viz., an endless chain hanging over the top of the wagons and driven by a small portable engine geared at about 3 to 1. The links of the chain are caught by a fork made fast to the wagon frame. Double roads; gauge, 2 feet 8 inches; gradients and curves, easy; speed, about two miles per hour; carrying capabilities, about 500 tons daily. Estimated cost per ton per mile, 4d.

ENDLESS ROPE.

This system of haulage is being worked by Messrs. Elorduy and Co. from their Casualidad mine to the 6·6 mile Galdames Railway. Distance about 2,616 yards. It consists of a single road with shunts or pass-byes;

motive power, a small portable engine; rope, $\frac{3}{4}$ inch diameter. The tension of the rope is regulated by a balance carriage and counter-balance weights. Average gradients, 1 in 8. Carrying power, 400 tons daily. The author is of opinion that this system would give better results if there were a double road and the wagons being made to clip on at regular intervals, and not in single loaded and empty trains, which causes irregular strains on the rope and driving terminus. The endless rope or chain systems might have been profitably worked in many instances in the Triano mines.

RAILWAYS.

Ferro Carril de la Diputacion or the Deputation Railway is a Spanish enterprise and a very profitable undertaking, having paid as much as 60 per cent. in dividends. It was opened in 1859, and is a single line between El Desierto and Ortuella; 4·84 miles to the beginning of the deposits, and 5,22 miles long, including deposits; gauge, 5·5½ inches; maximum gradient, 1 in 60; average, 1 in 100. Curves not less than 163 yards radius. No heavy work. One iron-girder bridge over the river Galindo, and three small stone bridges. The total rise from end to end of the railway equals 61 yards.

This company possess 11 locomotives, and nearly 400 seven-ton end-tip wagons (Ashbury Company's). They have been carrying about 3,000 tons daily, but have carried double when pressed. They employ about 300 men in loading gang. Rate charged, about 20 pence per ton f.o.b. Ortuella to El Desierto; this includes loading, transport, and discharging into vessel's hold. The present deposits at Ortuella are capable of holding about 500,000 tons of ore. This company have three low-loading tips and two high or new tips working 16½ feet above high-water mark, and have contracted for the erection of two more tips and two basins for loading coke and pig iron, also about 160,000 cubic metres of embankment in conjunction with these tips, their object being to load 10,000 tons of ore daily. Nearly 1¼ million tons were shipped in 1881 and 1882 (11 months.)

Approximate cost of railway, etc. :—

	£
Railway workshops, fixed materials, plant, walls, and deposits ...	130,000
Loading stages and drops	8,000
Rolling stock and locomotives	55,000
	£193,000
Estimates of new tips, basins, embankment, and ore deposits at Ortuella	100,000
Total	£293,000

$1\frac{1}{4}$d. per ton is paid by this company to the Marquis of Mudela for right of passage to the new tips.

Ferro Carril de Galdames á Sestào (*Bilbao Iron Ore Company, Limited*). —This line was opened in 1876, and is a double line of about 4 feet gauge. Total length, 14 miles, including deposits; up road, iron rails 56 lbs. per yard; down road, steel rails 56 lbs. per yard; gradients vary from 1 in 45 to 1 in 100. The railway commences with a tunnel 680 yards long. There are four miles of heavy gradients, and for a large portion of the way there are some heavy cuttings, embankments, and sharp curves (87 yards radius); also three tunnels 154, 200, and 121 yards long respectively, a large bridge at Galindo, three viaducts 80, 53, and 40 feet high, and several culverts and drains; the last 9 miles of the railway are nearly level. This company transported about 650,000 tons last year.

As the dip outcrop of ore or base of Triano mine is visible in Catalina mine (south-west side), in Bodovalle station, this railway is favourably situated for attacking the focus of this and adjacent mines. The above-mentioned outcrop is about 11 yards above the level of the rails in the station. This company are erecting a new tip to improve their loading arrangements. They possess seven large and four small locomotives, the former with four-wheeled bogies to guide them when running round sharp curves, which act very well; the rolling stock consists of 506 six-ton bottom-door opening wagons, two tanks, and several ballast wagons. The total rise of the line is 144 yards. This is about half-way between Sestào and Galdames stations. The approximate cost of railway stations, branch lines, piers, work-shops, plant, materials, rolling stock, locomotives, and sundries, is about £700,000.

El Regato Railway (*Luchana Mining Company, Limited*).—This railway is standing at present, and extends from Luchana to El Regato; single line with sidings at intervals; gauge, 3 feet $4\frac{3}{4}$ inches; total length 6·3 miles; of this, about half has been laid. Average gradient, 1 in 55. At the terminus of the railway there is an incline 980 yards long, inclination 1 in 3·3. Rolling stock, 200 six-ton end-tip wagons, and two locomotives. Mines require opening out. Total cost of railway constructed, etc., £60,000.

The Orconera Railway (*Orconera Iron Ore Company, Limited*).—Inaugurated 1877, from Luchana to Gallarta. Double line, total length $7\frac{1}{2}$ miles; gauge, 3 feet $4\frac{3}{4}$ inches; total rise, 218 yards; average gradient, 1 in 44. This company possess ten large locomotives and four small

ones; the rolling stock consists of 418 seven-ton bottom-door opening wagons, 82 4½-ton inclined plane wagons, and 22 ballast wagons. The company have carried 6,000 tons per day when pressed. Over 1,000,000 tons were loaded by the company in 1883, and they possess the best loading arrangements in Bilbao river, as steamers can be loaded at any state of the tide by means of admirably arranged telescopic trunks or hopper-drops, which can be lowered or raised as required to suit steamers. The company also possess a very fine inclined plane from their Orconera mines to which reference has already been made. The mines leased cover an area of nearly 600 acres. In their Cesár and Matamoros mines may be seen very good methods of quarrying, viz., by driving a tunnel under the centre of the floor of the mine, and loading direct from the faces through spouts into railway wagons.

The total cost of construction of the railway, inclined plane, tips, quay walls, mine plant, shops, rolling stock, etc., was about £450,000.

The Concha Railway (*Franco-Belga Company*).—Opened 1880. Single line; steel rails, 40 lbs. per yard; runs nearly parallel to the Deputation Railway, but 16½ feet lower. It is a model of a cheap and well-constructed line, and capable of carrying a very large quantity of ore if required. Its length is a little over 4½ miles from Luchana to the deposits (Rio Granada station); gauge, 3 feet 4¾ inches; difference of level at ends, about 90 feet; easy gradients. Average quantity of ore carried daily, 800 to 1,000 tons. The company possess four locomotives and about 120 6-ton wagons, opening at the bottom; also two loading stages and several inclines, and an endless chain system of haulage (already referred to). 150,000 tons of ore were loaded between 1882 and 1883 (one year).

Approximate cost of railway, lands, plant, etc., about	£85,000
Shoots, piers, and quay walls	35,000
Total	£120,000

La Salve, or Alonsos Branch Railway.—Opened 1881. Single line; narrow gauge, 2 feet 6 inches; length, 1·86 miles, from top of Ortuella inclined plane to Esperanza and San Severino mines; gradients, 1 in 50 and 1 in 60; steel rails, 32 lbs. per yard; rolling stock, 60 to 70 three-ton wagons, opening at the side; and three small Belgian locomotives. Carrying capabilities, 1,000 to 1,200 tons per day; average carried, 600 tons daily. Total cost, £15,000.

Details.	Name of Railway.				
	Triano or Deputation	Galdames.	El Regato.	Orconera.	Concha.
Total length of line, in miles ...	5·22	14·0	* 6·3	7·5	4·5
Gauge of line in feet	5·5½	4·0	3·4¾	3·4¾	3·4¾
Number of roads	1	2	2 & 1	2	1
Minimum radius of curves, in yards	163	87	120	109	131
Maximum gradient	1¾ %	2·22 %	1·80 %	2·50 %	1¾ %
Class of rails	Iron	Iron & steel	Steel	Steel	Steel
Weight in lbs., per yard	54	56	35	45	40
Number of locomotives	11	11	2	14	4
Number of wagons in tons... ...	400	506	200	522	120
Capacity of wagons	7	6	6	7	6
Average speed of trains	From 8 to 14 miles per hour.				
Number of wagons per train ...	20 to 30	30	25	25	25
Number of trains per day	Vary from 10 to 20 per day.				
Tons loaded daily, average ...	2,500 to 3,000	2,000	Standing	2,000 to 3,000	800 to 1,000
System of discharging wagons ...	End tip	Bottom	End	Bottom	Bottom
Difference of level between extreme ends of railway, in feet ...	183	432 and 358	272	656	89
Height of tips above sea level, in feet	20 and 36	32	32	28	33

* Half only finished.

From the foregoing data it will be seen that the modes or systems of transport and working of mines in Triano Mountain are extensive and varied. Upwards of 3,500,000 tons of iron ore are shipped or loaded into steamers annually at a cost of about 6s. per ton f.o.b. The capital invested, exclusive of plant in quarries, may be roughly calculated as follows, viz.:—

Value of railways, etc.	£1,500,000
„ discharging stages and stations, plant, etc.	265,000
„ deposits, shoots, stations, plant, &c. ...	250,000
„ wire tramways	125,000
„ inclined planes	100,000
„ bullocks and carts	25,000
„ cart roads, canals, barges, etc., etc. ...	18,000
Total, about	£2,283,000

APPROXIMATE COST OF GETTING, TRANSPORTING, ETC., PER TON.

Average cost in a fair average mine :—

Getting and boring, about 1s. 6d. to 2s. per ton campanil or rubio mine.
Royalty, about ... ... 1s. „ „ „
Transport from mine to railway 6d. to 1s. „ „ „
Transport by railway 1s. 6d. to 2s. „ „ „
Contingencies, redemption of capital and interest, etc., about 6d. „ „ „

or say from 5s. 6d. to 6s. per ton f.o.b. In some mines where ore can be got cheaper the figure would be about 5s. per ton f.o.b.

The approximate proportions of ore carried by different methods are as follows, viz.:—By incline and wire tramways, about two-thirds; by bullock-carts, mules, shoots, and other means, about one-third. The whole of the above ore is carried by railways with the exception of about 15 per cent. which is loaded into barges direct.

An intelligent authority has given the following as the proportion of ores found in Triano Mountain, viz.:—

Rubio (brown ore) about	50 per cent.
Vena (soft red ore) about	25 „
Campanil (red hæmatite) about	25 „

and it has been lately estimated that there remains about 30,000,000 tons of good workable ore in Triano Mountain; hence if the present output of about 3,000,000 tons yearly is maintained, another ten years would suffice to work out the mines in Triano district. The author is of opinion that this calculation is not far wrong; at any rate the campanil and vena are fast being worked out. Another 20,000,000 tons of ore (principally rubio and vena) may be reckoned upon in the other adjacent mining districts, but the quality is not supposed to be so good as in Triano mines. It is reckoned that there are nearly 20,000 inhabitants distributed over the mines, principally miners.

The percentage of ore shipped to the middle of last year was about

England	60 per cent.
France, Germany, and Belgium	30 „
Spain	10 „

ORE SHIPPED FROM BILBAO MINES DURING THE LAST FOUR YEARS.

NATIONALITY.	WHEN SHIPPED.			
	1879.	1880.	1881.	1882.
	Tons.	Tons.	Tons.	Tons.
England	730,000	1,687,000	1,713,000	2,450,000
France	203,000	245,000	345,000	450,000
Belgium	45,000	83,500	88,000	178,000
Holland and Germany...	122,000	295,000	336,000	598,000
America...	17,000	35,500	18,000	16,000
TOTALS	1,117,000	2,346,000	2,500,000	3,692,000*

* The total tonnage has somewhat fallen off during 1883 from that of 1882, being 3,428,000.

BILBAO PORT AND RIVER IMPROVEMENT.

The entrance to the river and port of Bilbao is over a dangerous sand bar, which has been the cause of many wrecks. The remains of several vessels are now to be seen on the left-hand bank at the entrance, hence this has been, and still is (though considerably improved) the great drawback to this place in rough weather. Further, as the river has three sharp bends and is narrow in some places it has necessitated the following work, viz.:—

1.—Deepening the bar.
2.—Dredging to straighten and deepen the river.
3.—Dredging out a dock for loaded vessels.

The above works include a large amount of masonry and iron-work for training the pier over the bar.

First, with regard to the deepening of the bar. An iron pier and wall (shown in red in Plate XX.) have been run out about 800 yards, the projected length being 860 yards; radius of curve, 3,000 metres, or 3,280 yards; the figures on the blue lines show the depth of water in metres. Its construction is as follows, viz.:—Two wrought iron longitudinal girders, crossed by wrought iron joists, form the upper portion. These are supported by strong forged iron piles fitted into the socket of a helical screw, and secured by a cotter (riveted head); a concrete wall running between screw piles supports and sustains the pier against heavy seas; the top of the wall is level with equinoctial high-water mark, and 8¼ yards above equinoctial low-water mark. The sea-end of the wall and pier is to be 3¼ yards higher, to resist breakers on the bar in heavy gales, upon which will be built a lighthouse and pier and harbour-master's house. The basement or foundation of the pier and wall consists of dry rubble, and it was proposed to tip large concrete blocks fifteen to thirty tons weight on either side of the pier for the wall to act as a protection in heavy gales; but the harbour engineers have changed their minds and simply tip large blocks of freestone from quarries in Axpe. These vary in weight from two-and-a-half to five tons each, and are brought down from the quarries on barges to the south end of the pier, and lifted out by a couple of Appleby's portable steam cranes on to lorries; these are run on to the pier and tipped where required. The smaller rock or stone is also brought down by barges, lifted by a small overhead travelling winch, on gantry arrangement, deposited by a stone-breaker, and broken into 3-inch cubes. The concrete-mixer is stationed directly over the bay that requires filling. It is worked by a small portable engine, and the whole being on wheels can be removed as the work

proceeds. After mixing is concluded the contents are dropped through a spout where required; this has to be done at low water, and in several battened-up sections, and as the battens forming the divisions have to be taken out as soon as the placing commences, little time for settlement is left. The mixture varies as follows, viz. :—From one of lime to four of stone, two of sand to one of lime, and two of stone to one of sand; the lime is quick-setting and a little over half the tensile strength of good Portland cement. The iron-work of the pier was erected by an agent representing a Barcelona firm from the plans of an English engineer, and all went well till October, 1882, when a tremendous gale swept along the Cantabrian coast and carried away 20 metres of the sea-end, including shear-legs, winch, and portable engine for screwing in piles, only leaving 630 yards intact. The iron-work was considerably in advance of the concrete and rubble-work. The sea on this occasion rose more than 3 feet higher than usual and made a clean breach over the river walls. On the 7th December following a strong N.E. gale drove the s.s. Rhyl through the middle of the pier for about half her own length, but she backed out astern without damaging herself, leaving a clear gap 10 metres wide. On the 11th of the same month the s.s. Saintonge was thrown broadside on against the pier and on to the top of the rubble, and carried away thirteen bays, equal to 85 yards; she was got off the following day slightly damaged, thus leaving a total length of iron-work carried away of 104 yards, which caused a great amount of trouble and expense to repair, the old piles having to be cut out and straightened, new ones being screwed in where necessary. Some of the accidents that have occurred when crossing the bar may be traced to the steamers trading here having very flat bottoms and being bad to steer.

The number of steamers that have gone out during 1882 and 1883, is 4,700; average registered tonnage, 700 tons; the total export tonnage between 1882 and 1883 was 3,700,000 tons; nine-tenths of this was iron ore.

The 600 metres of rubble basement work, tipped to date, is nearly 70,000 tons, and about 32,700 cubic yards of concrete placed in the wall.

The above-named work has induced a scour that has deepened the bar about six feet, but it has also narrowed the entrance considerably.

About 800 yards of walling have been put in on the right-hand side of the river, and 600 yards on the left-hand side, leaving about 2,616 yards of river walling still to build. There is also a dock to dredge, covering an area of about 26 acres, for loaded vessels, the depth of which is to be 20 feet at low water ordinary spring tides.

There are nearly 2,600,000 cubic yards of spoil still to dredge between Bilbao and Portugalete, and about 327,000 cubic yards of river walling with some masonry to build.

The following are some of the contract prices for masonry, etc.:—

	Reals per Cubic Metre.	Per Cubic Metre. £ s. d.	Per Cubic Yard. £ s. d.
Dry rubble	35 ...	7 0 ...	5 3
Ordinary rubble	60 ...	12 0 ...	9 0
Ordinary concrete	40 ...	8 0 ...	6 0
Hydraulic rubble	75 ...	15 0 ...	11 0
Hydraulic concrete	80 ...	16 0 ...	12 0
Stone-work in quoins and walls ...	200 ...	2 0 0 ...	1 10 0
Ordinary brick-work with common mortar	150 ...	1 10 0 ...	1 2 6
Brick-work in arches	180 ...	1 16 0 ...	1 7 0
Plain ashlar-work, sandstone ...	320 ...	3 4 0 ...	2 8 0
Cut and dressed hard stone-work...	360 ...	3 12 0 ...	2 14 0
Stone pitching from ...	30 to 55	...6s. to 11 0	...4s. 6d. to 8 3
Excavation from ...	10 to 12	...2s. to 2 6	...1s. 6d. to 1 10½
Embankment	5 to 7	...1s. to 1 6	... 9d. to 1 1½

The pier or jetty has cost to date about £78 per yard, but it must be borne in mind that there is about 328 yards of concrete wall yet to build to make up to the 874 yards of iron-work erected. The total amount of work done to date is as follows:—

	£
Iron-work, timber-work, and estimate of lighthouse	25,000
Rubble basement	29,000
Concrete wall to high-water level	16,000
	£70,000

Buoys chained to screw piles are being placed about 218 yards apart between Portugalete and Luchana.

The total estimated cost of plant and material for dredging purposes belonging to the Contractors and Harbour Board is about £65,000 to £70,000. The greatest part of this has come from England, and includes 3 ladder dredgers, 1 of Bruce and Batho's hydraulic diggers, 10 Priestman grabs, 2 steam hopper barges, 1 tug-boat, 14 bottom and side-opening barges for the dredging-soil, and a number of hulks and barges for various other purposes, so that about 3,300 cubic yards of soil could be dredged daily and disposed of, if the condition and arrangement of sea and river were always favourable. As half of this quantity of soil has to be carried out to sea the average falls considerably below that figure. The

price of dredging varies from 5 to 6 reals per cubic metre (10d. to 1s. per cubic yard). Taking the preceding data and the following statement into account, an idea may be formed of the work done and to be done in Bilbao river, and the means at hand to accomplish it.

Before annexing the statements referred to, the author would take the liberty of making the following brief remarks on the works generally.

The pier or jetty should have been carried out on the opposite side of the river entrance, as sea currents set into and return from Algorta and Las Arenas and form immense sand-banks, which are continually drifting into the river channel, that being the side they are all carried from; and in the prevailing north-west gales steamers could run in from under the lee-side of Mount Serantes straight for the channel entrance.

At present there is more water on the bar than hitherto, caused by the river scour. The draft of water on the bar at high-water, in 1881, was 15 feet, and in 1883, 20 feet. The scour loses its power as it leaves Portugalete, hence the channel becomes narrower, and if a vessel takes a shear in a heavy sea and comes in over the bar broadside on, which has frequently been the case, she runs a great risk of striking the pier or running into sandbanks.

The size and draught of vessels have increased considerably during the last two years, which increases the risks.

It may be that the Chamber of Commerce or Harbour Board have not concurred with the ideas of the Port Engineer in deciding the site or direction of the pier (as was the case with Gijon harbour), and have departed from the regulations laid down by the Government engineers with regard to harbour works on the north coast of Spain, purely from commercial, private or personal motives.

SUNDRY STATEMENTS RELATING TO RIVER WORK.

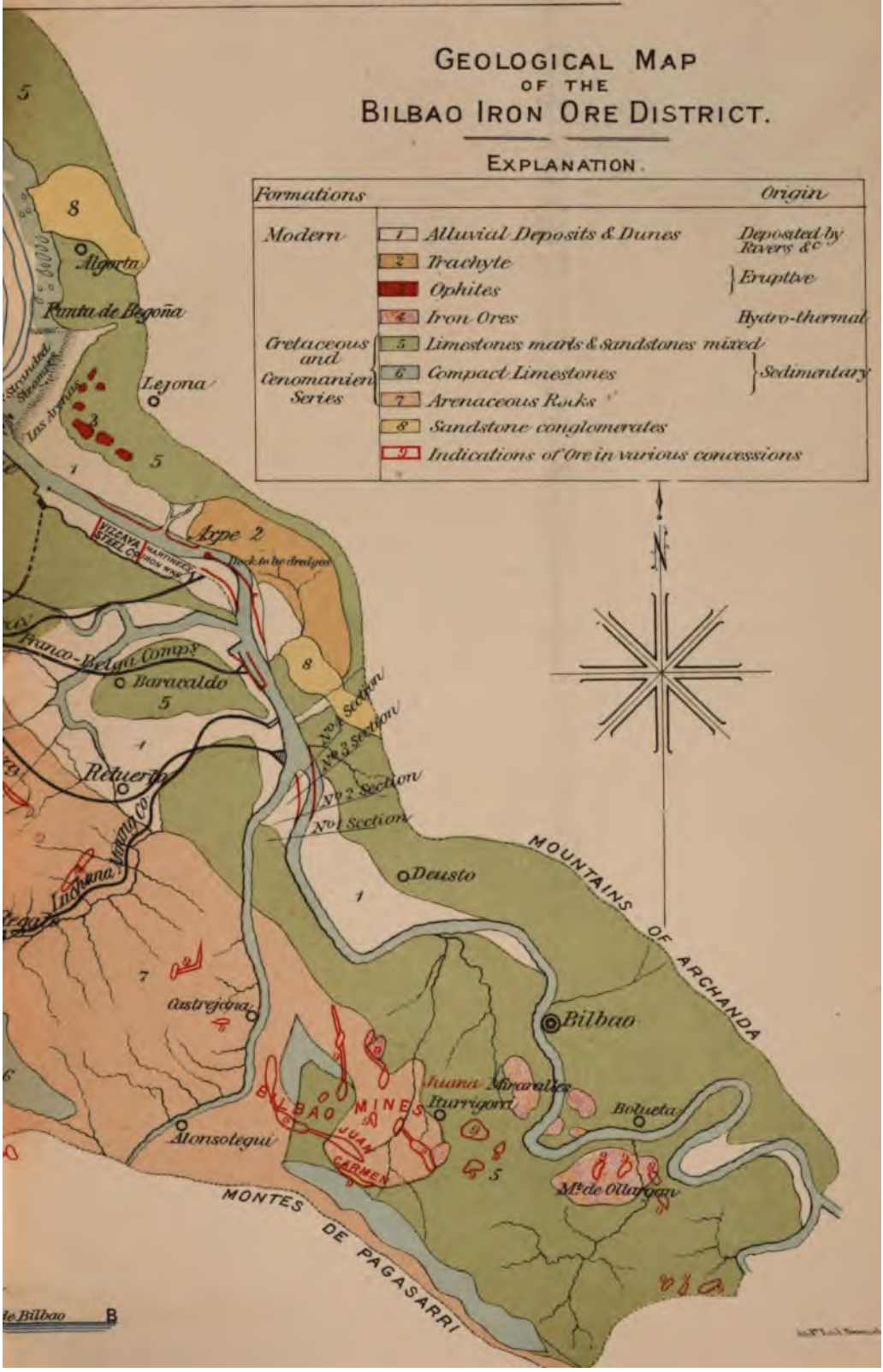
AMOUNT OF CONTRACTS LET.

	£
New cut, Elorrieta (concluded)	52,000
Upper-half of river masonry and dredging (half-finished) ...	102,500
Lower-half of river masonry, walls, &c. " ...	105,000
Lower-half of river dredging ... ... " ...	70,000
Dock at Axpe, dredging	35,000
Fixing buoys and bollards (nearly finished)	8,500
Electric light and house arrangements (concluded)	4,200
Semaphore signals, lighthouse, electric light arrangement on Galea point	1,600
	£378,800

To illustrate Mr. B. J. Forrest's paper

Proceedings No. E.1 of M.M.E. 1883-84

the Bilbao Iron Ore Mining District.



To illustrate Mr. B. J. Forrest's paper "On the Bilbao Iron Ore Mining District."

FIG. 1. SECTION THRO' SAN BERNABE MINE.

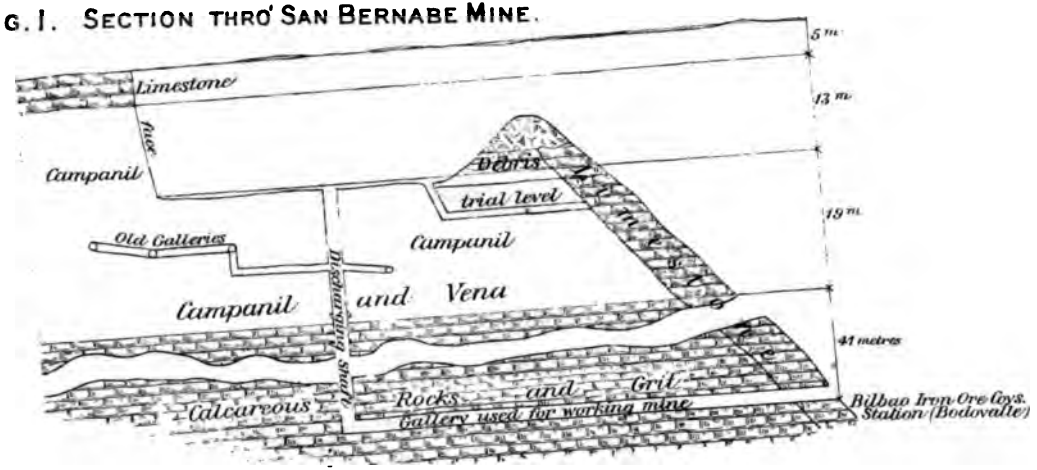
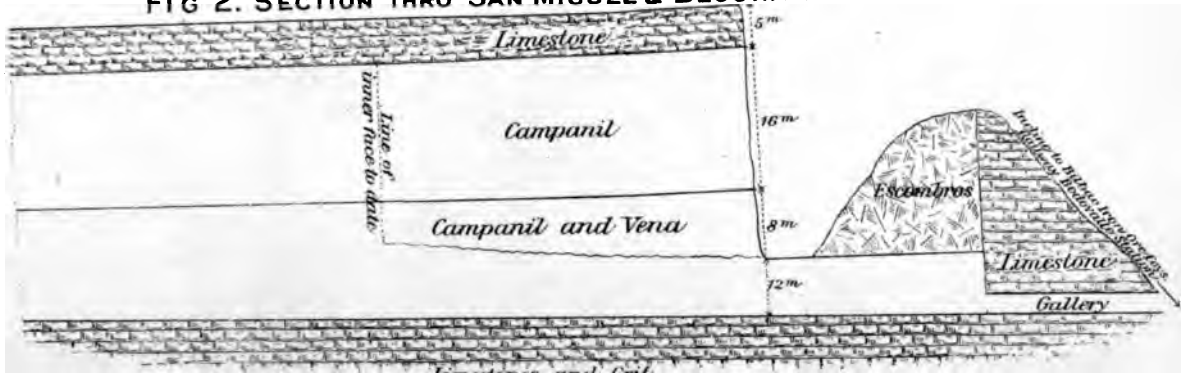


FIG 2. SECTION THRO' SAN MIGUEL & BEGOÑA MINES.



To illustrate Mr. B. J. Forrest's paper "On the Bilbao Iron Ore Mining District."

Cross Sections of River Improvements.

Fig. 1.

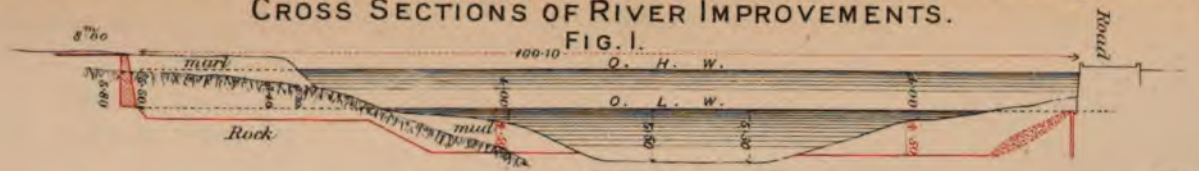


Fig. 2.

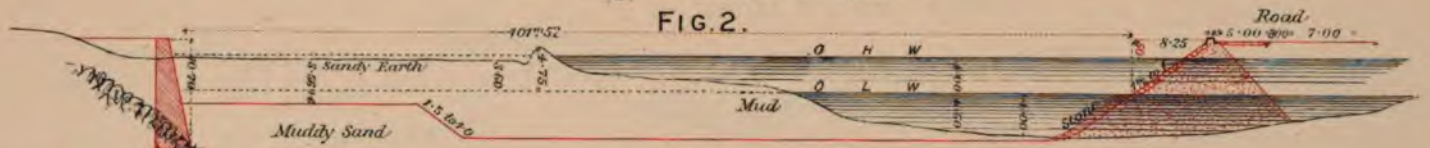
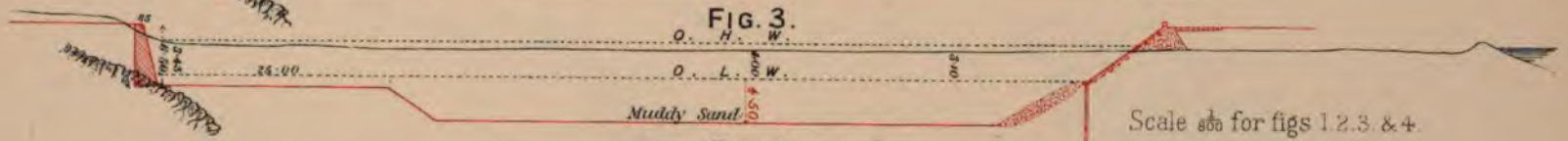
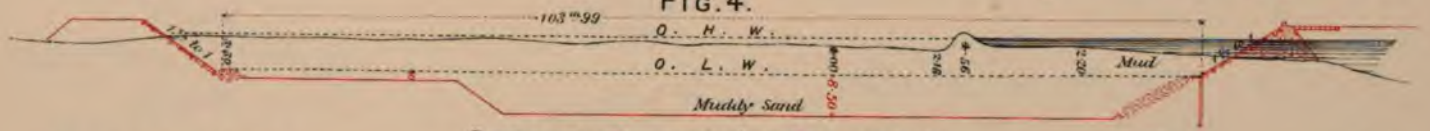


Fig. 3.



Scale $\frac{1}{500}$ for figs 1.2.3. & 4.

Fig. 4.



Sections thro' C.D. and E.F.

Triano Mines

Fig. 5.

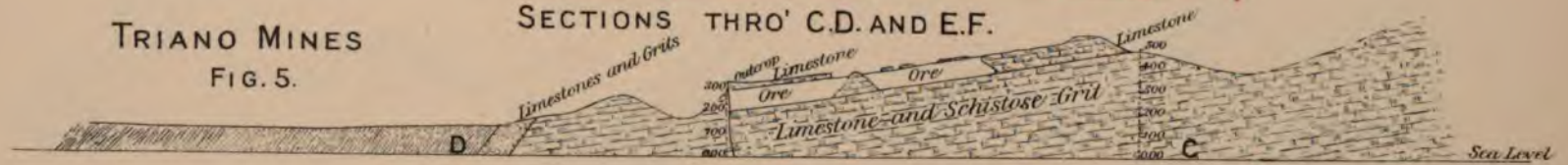
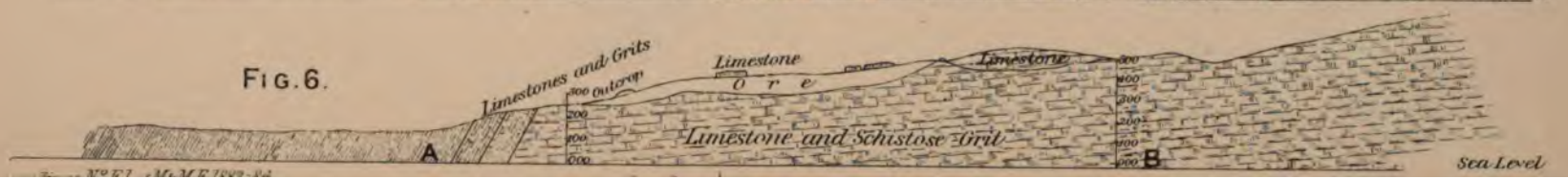


Fig. 6.



To illustrate Mr. B. J. Forrest's paper "On the Bilbao Iron Ore Mining District."

CONCHA MINES.

FIG. 1.
CROSS SECTION THRO' I.

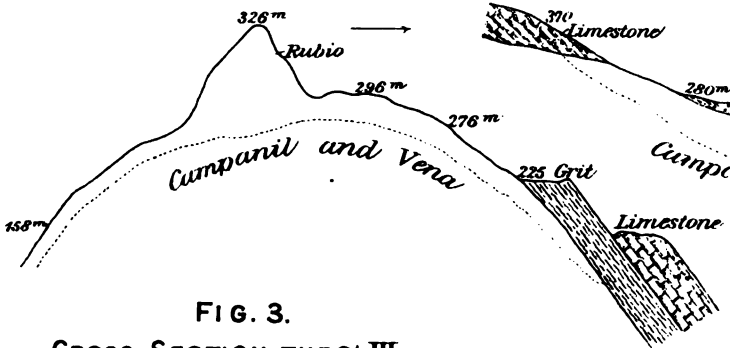


FIG. 2.
CROSS SECTION THRO' II.

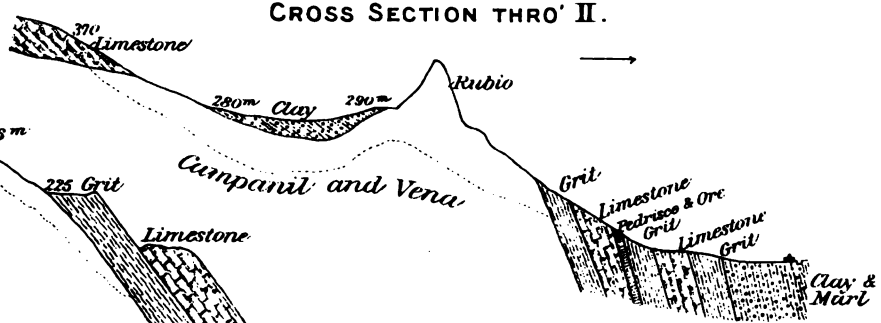


FIG. 3.
CROSS SECTION THRO' III.

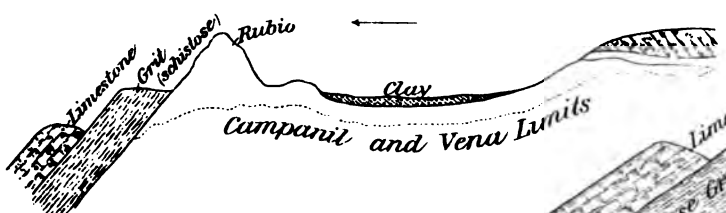
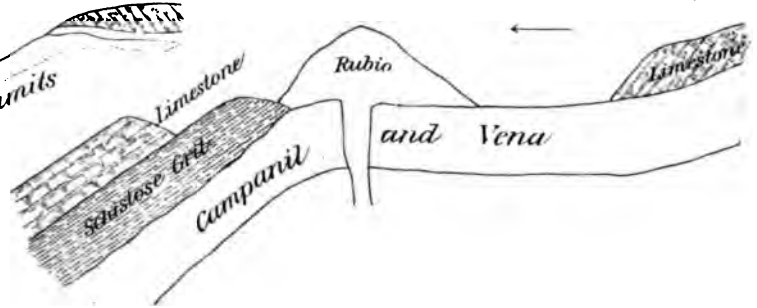


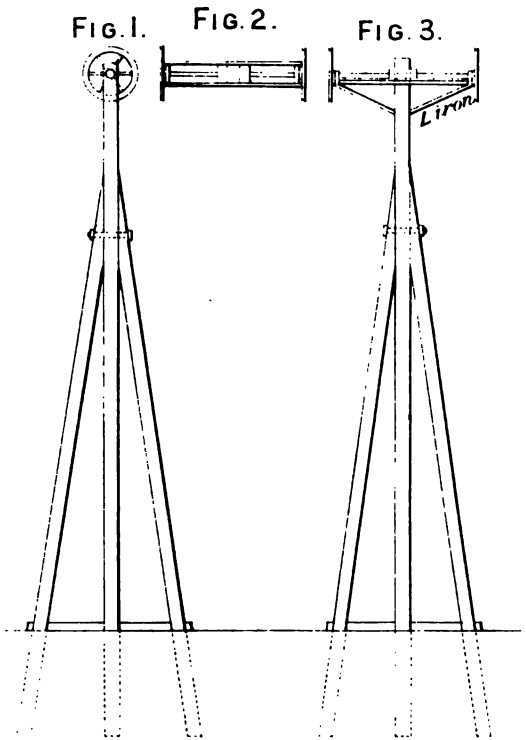
FIG. 4.
CROSS SECTION THRO' IV.



Ant. Reid Newcastle.

To illustrate Mr. B. J. Forrest's paper "On the Bilbao Iron Ore Mining District".

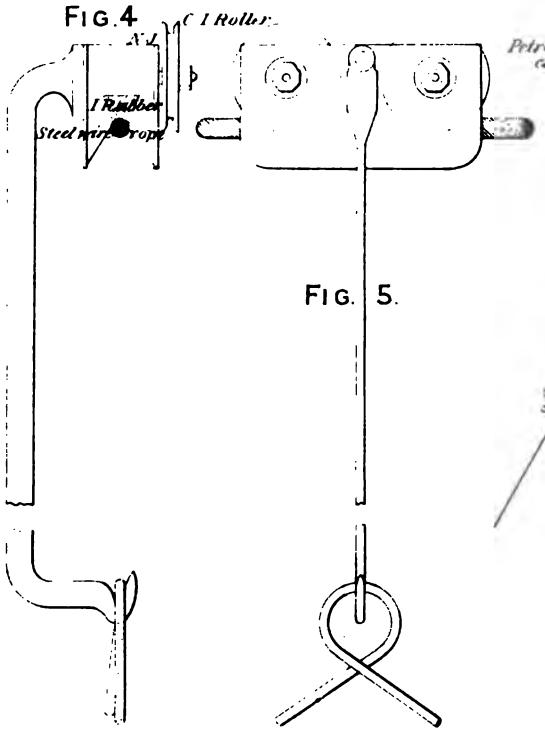
HODGSON'S SYSTEM OF WIRE TRAMWAYS.



Scale $\frac{1}{48}$.

TRESTLE

Single Line



Scale $\frac{1}{6}$

BOXHEAD

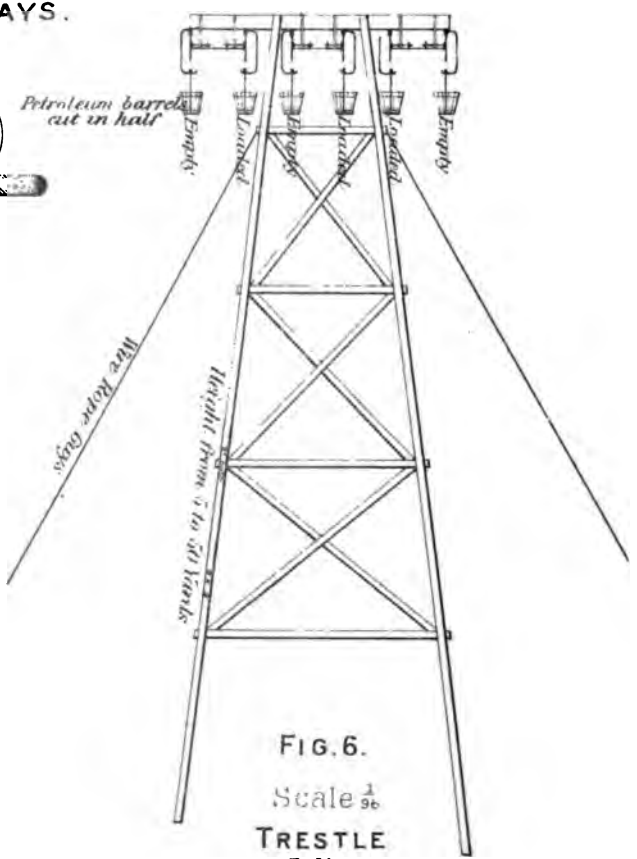


FIG. 6.

Scale $\frac{1}{96}$

TRESTLE

3 lines

To illustrate Mr. B. J. Forrest's paper "On the Bilbao Iron Ore Mining District."

SELF-ACTING TRAMWAYS — BLEICHART'S PATENT.

Rope clips — for steep Gradients.

Scale ¼ in. = 1 foot.

FIG. 1.

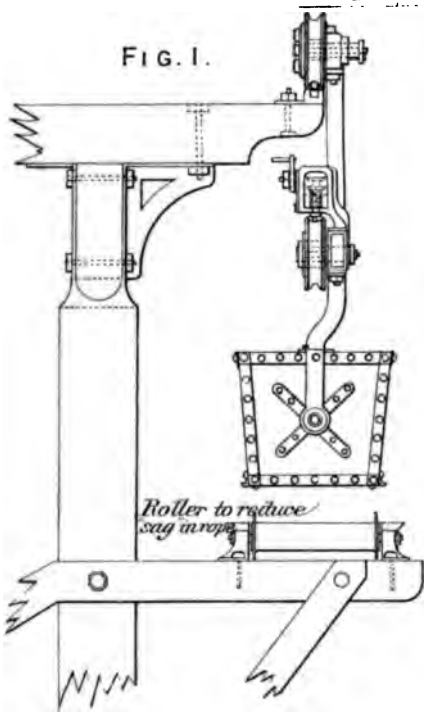
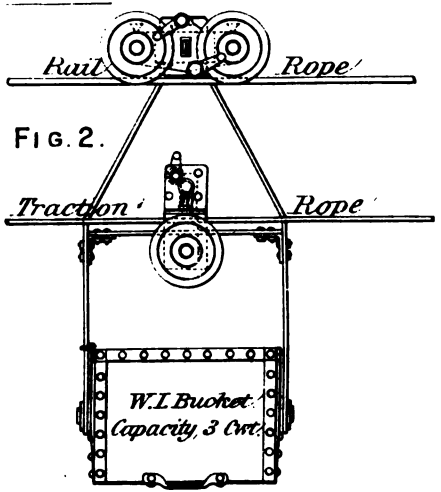


FIG. 2.



Rope clips for easy gradients.

Scale ¼ in. = 1 foot.

FIG. 3.

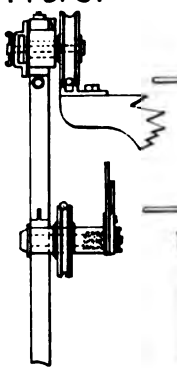


FIG. 4.

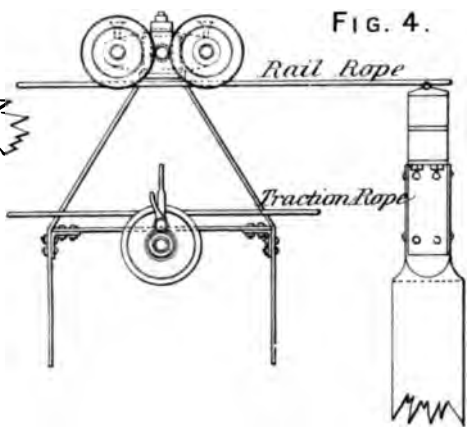
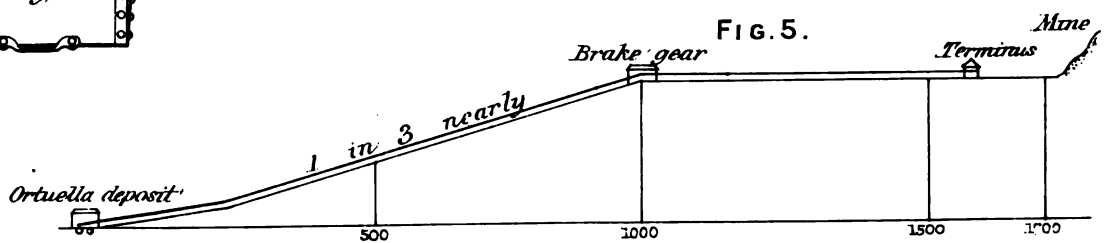


FIG. 5.



Drawings No. E1 of M.M.E. 1883-84.

The total amount paid on said contracts to date (June, 1883), may be divided as follows:—

	£
Office and general expenses	1,700
Studies, expenses of	600
Expropriation of land	24,000
Dredging and masonry, new river cut (Elorrieta)	48,000
Dredging river, lower-half, to date	47,000
Masonry, " " "	48,000
Dredging river, middle portion, to date	12,000
" " upper " "	28,000
Harbour Board's dredging plant	26,000
Buoys and moorings	2,200
Electric light arrangement	1,800
Blowing up sunken wrecks	25,000
Maintenance of river walls	2,000
Administration	1,200
Inspection by Government	130
Interest on loan	6,000
Total	£273,630

The total revenue from January, 1878, to June, 1883, was nearly £290,000; expenses, as per preceding statement, £275,000; balance in hand, 30th June, 1883, £15,000.

AVERAGE PRICES OF IRON ORE.

Port.	1882. s.	d.	1883. s.	d.	Decrease per Ton. s.	d.
Newport ...	8	6	5	9	2	9
Cardiff ...	8	0	5	6	2	6
Tyne	9	6	7	0	2	6
Glasgow	9	6	7	0	2	6
Rotterdam ...	11	0	7	6	3	6
Amsterdam ...	11	3	7	6	3	9

Mr. Thomas E. Candler's paper "On Thompson's Patent Centrifugal Pulverizer" was then announced to be open for discussion.

Mr. THOMPSON, the inventor of the machine, said that Mr. Candler was in China, and he (Mr. Thompson) had thought it best to attend the meeting to answer any questions members might desire to ask.

The PRESIDENT asked Mr. Thompson if he wished to add anything to the paper?

Mr. THOMPSON replied, that practical men asked how he was going to keep the grit out of the bearings of the machine. Mr. Candler in the paper referred to some improvements, but at that time the patent was only provisional and the improvements were kept secret. The new arrangement consisted of utilising the inward flow of the feed-water by directing it through a water-bearing on the mill shaft, so that it flowed around the shaft and entered the mill in a circular jet, which entirely prevented the escape of pulp or grit except through the proper channel. It was necessary to have water running into the hopper when grinding mineral, quartz, etc., and when these improvements were practically applied to machines in use at Bristol and Greenwich a saving of one-third the power was effected. The machine had also been used for grinding coal, and the ball used lasted exceedingly well and kept its spherical shape. The balls were made of hammered steel all through, and were the hardest that could be obtained. For coal-grinding, particularly where the coal was required to be ground fine, there could not be a better system than the pounding action which was very rapid. The machine will grind coal either wet or dry.

The PRESIDENT said, when he spoke of wet coal, he did not mean coal with water, but coal that had been washed. When coal was mixed with stone or foreign matter, it was necessary to wash it to get rid of the foreign matter. It has been found that some machines, worked for the purpose, would not grind damp coal, but possibly this would.

Mr. THOMPSON—It certainly can grind damp coal.

The PRESIDENT—That is a great point. In many places machines cannot be applied on account of the necessity of washing the coal.

Mr. THOMPSON said, the crushing action was equal, and continued the same. The discs were set with so little pressure on the ball as to allow it to slip to the bottom of the ring when they were slowly turned. But when they were running at their proper velocity this slight contact was sufficient to carry the ball over and keep it rolling. He had the testimony of Mr. Green, mining engineer, who had had considerable experience in gold quartz grinding, that with this machine he saved two-thirds of the power. Many persons thought the ball was likely to bed in the discs. That never could take place; the ball was always changing its position, and when the discs were taken out they would be found to have a perfectly true surface.

Mr. THOMPSON exhibited gold quartz which had been ground at the rate of 16 cwt. per hour, with $6\frac{3}{4}$ indicated horse-power, and a ball of $8\frac{1}{4}$ inches diameter; also a sample of wheaten flour which had been ground by the machine.

The PRESIDENT proposed a vote of thanks to Mr. Thompson for his kindness in attending and explaining the machine. The machine had a very wide range of power—from gold quartz to wheaten flour; and there was no doubt that between the two extremes, the mineral which they were most interested in—coal—ought to come in. He hoped the machine might be of use to those who required something of the sort.

Mr. JOHN DAGLISH seconded the vote of thanks, which was agreed to.

The SECRETARY then announced the result of the Election of Officers for the ensuing year.

Mr. STEAVENSON proposed a vote of thanks to the retiring President for the very excellent manner in which he had presided over them during his term of office. It had been a great pleasure to them to meet Mr. G. B. Forster, who had seldom missed a meeting, and had sat through the longest meetings with the greatest patience, always giving them the benefit of his experience in a pleasant manner.

Mr. R. ROBINSON seconded the motion, which was unanimously agreed to.

The PRESIDENT said, that in bidding them good-bye, as their President, he had to thank them very much for the great kindness and assistance which every one, Vice-Presidents, Council, and Members, had always rendered to him. He was afraid that Mr. Steavenson had told too flattering a tale, but he (Mr. G. B. Forster) could say that he had done the best in his power, and hoped he had not neglected the Institute. Although the last three years had been rather what they called a stationary period, owing to the depression of trade and various other causes, yet on the whole the Institute had not lost ground; and this, as the reports of the Council and Finance Committee showed, was a point of some importance; because if they could hold their own in bad times they might look forward to being carried onward higher and higher when the wave of prosperity returned. He concluded by calling for a cheer for the new President, which was heartily responded to, and the meeting concluded.

BAROMETER AND THERMOMETER READINGS FOR 1883.

By the SECRETARY.

These readings have been obtained from the observations of Kew and Glasgow, and will give a very fair idea of the variations of temperature and atmospheric pressure in the intervening country, in which most of the mining operations in this country are carried on.

The Kew barometer is 34 feet, and the Glasgow barometer 180 feet above the sea level. The latter readings have been reduced to 32 feet above the sea level, by the addition of ·150 of an inch to each reading, and both readings are reduced to 32 degrees Fahrenheit.

The fatal accidents have been obtained from the Inspectors' reports, and are printed across the lines, showing the various readings. The name of the colliery at which the explosion took place is given first, then the number of deaths, followed by the district in which it happened.

At the request of the Council the exact readings at both Kew and Glasgow have been published in figures.

BAROMETER READINGS, &c.

JANUARY, 1883.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·768	29·808	29·747	29·702	54·8	52·0	1	29·829	29·891	29·921	29·984	50·9	42·0
2	29·707	29·710	29·660	29·616	52·4	44·6	2	29·948	29·942	29·841	29·755	49·0	35·3
3	29·805	30·005	30·074	30·136	48·8	42·6	3	29·569	29·494	29·514	29·644	41·4	35·5
4	30·147	30·169	30·162	30·195	45·6	39·6	4	29·738	29·866	29·919	30·015	40·9	34·9
5	30·195	30·203	30·139	30·213	48·8	39·6	5	30·021	30·057	30·066	30·108	46·0	41·0
6	30·317	30·389	30·414	30·438	44·7	35·9	6	30·177	30·278	30·285	30·287	44·0	39·0
7	30·447	30·445	30·375	30·345	40·5	37·6	7	30·233	30·260	30·297	30·345	43·2	33·2
8	30·267	30·198	30·111	29·985	40·3	32·0	8	30·365	30·417	30·379	30·318	35·2	30·0
9	29·881	29·740	29·615	29·564	39·3	33·8	9	30·191	30·125	30·095	30·087	39·0	35·0
10	29·565	29·601	29·537	29·508	42·5	36·9	10	30·050	30·023	29·928	29·884	40·2	37·8
11	29·523	29·577	29·603	29·611	42·7	40·1	11	29·830	29·866	29·889	29·959	41·5	38·0
12	29·586	29·574	29·462	29·381	41·9	38·3	12	29·991	30·013	29·925	29·882	38·1	37·0
13	29·252	29·267	29·320	29·408	45·6	36·4	13	29·784	29·725	29·645	29·646	42·2	37·0
14	29·491	29·544	29·480	29·398	43·1	35·6	14	29·574	29·511	29·438	29·486	42·0	38·5
15	29·277	29·359	29·373	29·432	47·6	38·4	15	29·485	29·486	29·362	29·080	44·9	39·1
16	29·508	29·731	29·866	30·009	44·7	33·3	16	28·946	28·812	28·846	28·972	44·0	37·0
17	30·052	30·115	30·136	30·142	47·6	30·7	17	28·934	29·076	29·098	29·201	49·4	43·3
18	30·127	30·133	30·137	30·248	50·3	41·7	18	29·313	29·472	29·559	29·616	48·8	37·9
19	30·312	30·304	30·183	30·138	49·9	35·5	19	29·560	29·519	29·426	29·425	48·7	36·8
20	30·136	30·234	30·244	30·289	49·0	42·1	20	29·385	29·402	29·405	29·484	44·2	35·8
21	30·306	30·361	30·375	30·422	49·3	43·3	21	29·574	29·708	29·800	29·892	43·0	35·7
22	30·430	30·500	30·513	30·598	43·3	37·0	22	29·887	29·830	29·637	29·436	44·0	40·0
23	30·612	30·625	30·545	30·515	39·8	30·1	23	29·330	29·367	29·389	29·363	41·4	36·9
24	30·402	30·242	30·025	29·709	38·5	30·1	24	29·463	29·497	29·400	29·210	47·4	36·7
25	29·539	29·636	29·587	29·229	43·4	36·1	25	29·020	29·381	29·514	29·693	39·9	33·8
26	29·046	29·225	29·287	29·432	47·1	34·7	26	29·785	29·863	29·771	29·631	37·3	33·3
27	29·659	29·613	29·372	29·575	49·5	35·4	27	29·650	29·833	29·973	30·071	37·4	33·4
28	29·929	30·110	30·054	29·751	50·1	35·5	28	30·061	30·064	30·028	30·063	48·1	33·9
29	29·631	29·514	29·459	29·498	52·2	41·4	29	30·079	30·188	30·241	30·321	50·2	32·9
30	29·569	29·630	29·643	29·659	44·2	34·1	30	30·343	30·375	30·337	30·334	41·3	32·4
31	29·554	29·489	29·421	29·430	40·3	29·3	31	30·245	30·216	30·036	30·168	36·3	28·3

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1	29·443	29·528	29·500	29·334	41·6	32·2	1	29·386	29·376	29·344	29·260	37·1	32·3
2	29·069	28·921	28·900	29·302	48·5	38·2	2	29·058	28·929	28·894	29·030	38·8	32·8
3	29·577	29·708	29·733	29·790	45·5	37·6	3	29·179	29·326	29·412	29·515	38·9	36·5
4	29·885	30·064	30·120	30·198	49·3	37·2	4	29·655	29·811	29·868	29·912	46·2	34·9
5	30·207	30·225	30·165	30·129	49·4	37·5	5	29·932	29·983	29·957	29·953	48·0	42·0
6	30·085	30·066	29·985	29·915	44·8	34·6	6	29·929	29·902	29·782	29·678	44·6	38·4
7	29·818	29·828	29·833	29·812	44·6	38·0	7	29·515	29·526	29·616	29·642	45·8	38·0
8	29·666	29·536	29·534	29·583	53·2	41·4	8	29·547	29·432	29·378	29·445	42·7	37·8
9	29·657	29·771	29·790	29·703	48·1	38·5	9	29·532	29·581	29·428	29·154	41·9	33·3
10	29·525	29·516	29·379	29·298	49·1	43·6	10	29·045	29·182	29·224	29·153	44·0	35·2
11	29·265	29·593	29·763	29·799	46·4	40·5	11	29·168	29·242	29·414	29·457	41·9	35·7
12	29·659	29·506	29·374	29·568	48·8	42·6	12	29·208	28·926	28·925	28·920	46·0	36·0
13	29·683	29·807	29·892	29·986	47·2	39·0	13	29·182	29·405	29·510	29·613	43·2	37·6
14	29·957	29·891	29·820	29·868	48·0	40·5	14	29·473	29·206	29·268	29·462	50·3	39·3
15	29·920	29·936	29·940	30·108	52·1	38·3	15	29·552	29·602	29·671	29·887	42·3	32·9
16	30·316	30·473	30·469	30·465	47·3	32·7	16	30·097	30·225	30·179	30·119	46·9	34·3
17	30·413	30·348	30·220	30·125	45·6	29·4	17	29·995	29·895	29·775	29·668	45·1	41·7
18	30·004	29·938	29·926	29·986	46·7	35·4	18	29·764	29·885	29·922	30·012	45·1	34·0
19	30·009	30·090	30·137	30·212	43·3	34·7	19	30·035	30·068	29·992	29·862	41·9	33·7
20	30·233	30·255	30·238	30·305	47·4	35·5	20	29·771	29·848	29·868	29·907	49·3	42·1
21	30·364	30·430	30·404	30·419	52·7	44·3	21	29·964	29·972	29·971	29·920	49·9	47·2
22	30·351	30·404	30·511	30·682	54·7	38·5	22	29·916	30·153	30·309	30·417	48·6	38·8
23	30·756	30·820	30·778	30·739	48·6	33·7	23	30·464	30·554	30·529	30·483	45·8	40·5
24	30·689	30·682	30·591	30·640	52·9	34·3	24	30·383	30·317	30·399	30·483	49·8	40·0
25	30·641	30·658	30·641	30·652	50·2	43·6	25	30·531	30·552	30·559	30·552	47·8	39·0
26	30·622	30·636	30·547	30·518	47·4	37·3	26	30·487	30·420	30·344	30·304	44·8	42·0
27	30·477	30·469	30·389	30·421	48·4	38·7	27	30·250	30·205	30·234	30·355	52·0	38·0
28	30·430	30·494	30·447	30·425	54·1	44·2	28	30·395	30·412	30·336	30·301	47·7	34·2

BAROMETER READINGS, &c.

MARCH, 1883.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·324	30·432	30·472	30·539	48·4	42·9	1	30·359	30·438	30·450	30·505	51·8	43·3
2	30·571	30·618	30·585	30·609	44·1	38·1	2	30·525	30·579	30·558	30·598	46·0	42·7
3	30·614	30·666	30·646	30·682	47·6	29·3	3	30·573	30·592	30·589	30·615	44·0	35·0
4	30·659	30·680	30·614	30·644	47·5	30·5	4	30·603	30·641	30·628	30·660	49·8	29·3
5	30·641	30·608	30·466	30·381	53·5	30·4	5	30·641	30·611	30·485	30·444	49·3	35·3
6	30·246	30·169	30·079	30·057	41·6	30·7	6	30·325	30·372	30·370	30·392	43·0	33·0
7	30·040	29·965	29·840	29·727	37·1	29·8	7	30·322	30·186	30·050	30·015	38·0	31·3
8	29·666	29·738	29·803	29·897	34·6	25·4	8	30·010	30·062	30·153	30·189	37·8	30·8
9	29·908	29·954	29·926	29·913	34·9	25·0	9	30·160	30·114	29·976	29·892	40·8	32·0
10	29·859	29·850	29·798	29·805	35·3	24·3	10	29·860	29·856	29·842	29·865	41·2	32·1
11	29·744	29·685	29·631	29·634	39·9	26·3	11	29·819	29·782	29·719	29·814	43·2	30·0
12	29·681	29·817	29·903	29·985	39·5	28·3	12	29·868	29·929	29·935	29·955	41·8	28·1
13	29·991	30·012	29·943	29·877	42·7	27·9	13	29·924	29·897	29·823	29·770	43·4	28·7
14	29·761	29·725	29·642	29·637	45·0	33·1	14	29·757	29·778	29·770	29·785	38·0	29·0
15	29·603	29·605	29·613	29·655	37·3	27·0	15	29·742	29·709	29·671	29·637	37·0	27·0
16	29·613	29·573	29·490	29·486	40·6	24·1	16	29·532	29·398	29·356	29·433	45·0	27.7
17	29·498	29·507	29·460	29·514	45·6	32·1	17	29·392	29·366	29·429	29·488	36·6	27·0
18	29·532	29·603	29·637	29·734	44·8	30·8	18	29·475	29·464	29·520	29·670	37·1	30·6
19	29·734	29·739	29·686	29·659	41·9	34·1	19	29·742	29·845	29·843	29·864	40·0	30·1
20	29·618	29·620	29·598	29·591	41·7	37·5	20	29·821	29·803	29·774	29·752	37·8	33·5
21	29·542	29·590	29·664	29·829	40·7	35·3	21	29·741	29·818	29·896	30·082	39·7	34·4
22	29·940	30·089	30·110	30·181	35·3	30·4	22	30·215	30·329	30·367	30·414	35·1	31·4
23	30·158	30·160	30·075	30·094	37·7	26·4	23	30·375	30·340	30·187	30·084	37·1	28·3
24	30·034	29·958	29·803	29·825	45·3	22·6	24	29·884	29·795	29·874	29·905	48·2	31·5
25	29·837	29·770	29·536	29·298	43·0	28·3	25	29·786	29·427	29·186	29·258	45·2	29·6
26	29·183	29·232	29·230	29·249	44·2	30·0	26	29·198	29·202	29·207	29·340	41·8	30·7
27	29·350	29·494	29·658	29·849	42·5	27·0	27	29·440	29·572	29·621	29·793	42·8	28·7
28	29·927	30·058	30·119	30·180	43·3	27·6	28	29·891	30·013	30·021	29·975	40·0	26·7
29	30·143	30·095	29·906	29·752	48·1	28·5	29	29·815	29·663	29·408	29·127	43·6	33·9
30	29·547	29·372	29·387	29·636	52·4	38·0	30	28·941	28·984	29·166	29·317	46·3	36·6
31	29·968	29·903	29·973	30·111	53·0	31·6	31	29·442	29·629	29·808	29·980	45·6	35·2

APRIL, 1883.

1	30·200	30·282	30·239	30·251	55·3	29·8	1	30·066	30·138	30·108	30·075	50·9	36·9
2	30·164	30·096	30·006	30·041	62·6	32·4	2	29·962	29·865	29·778	29·850	55·9	40·7
3	30·091	30·181	30·188	30·220	63·6	37·3	3	30·021	30·156	30·138	30·140	52·9	38·2
4	30·213	30·236	30·176	30·191	63·6	41·3	4	30·086	30·087	30·074	30·070	51·2	37·1
5	30·181	30·213	30·193	30·285	64·9	36·6	5	30·037	30·114	30·261	30·382	52·8	40·3
6	30·396	30·492	30·525	30·605	56·4	40·0	6	30·478	30·552	30·547	30·586	55·3	35·2
7	30·619	30·628	30·554	30·571	53·3	33·9	7	30·565	30·534	30·511	30·511	56·3	36·3
8	30·533	30·525	30·444	30·450	52·3	35·5	8	30·485	30·483	30·421	30·420	57·6	30·0
9	30·417	30·398	30·266	30·283	58·4	31·3	9	—	30·397	30·353	30·389	56·1	36·8
10	30·334	30·394	30·347	30·374	50·2	35·7	10	30·397	30·393	30·321	30·312	57·2	41·0
11	30·351	30·348	30·234	30·237	57·3	32·7	11	30·275	30·289	30·272	30·283	59·9	41·5
12	30·216	30·183	30·084	30·057	54·6	39·3	12	30·220	30·168	30·058	29·934	51·2	42·2
13	29·964	29·889	29·804	29·812	48·4	41·0	13	29·778	29·710	29·701	29·775	52·7	39·9
14	29·822	29·843	29·814	29·863	56·2	49·5	14	29·800	29·778	29·729	29·669	51·1	37·1
15	29·861	29·867	29·845	29·878	57·7	39·3	15	29·553	29·526	29·562	29·642	51·4	38·9
16	29·937	30·025	30·032	30·070	55·1	40·4	16	29·667	29·681	29·733	29·776	46·5	37·4
17	30·041	29·999	29·851	29·760	55·3	35·4	17	29·715	29·625	29·480	29·410	51·5	40·1
18	29·584	29·531	29·446	29·544	64·1	41·3	18	29·255	29·191	29·247	29·370	50·0	39·8
19	29·541	29·576	29·703	29·831	49·3	44·2	19	29·473	29·578	29·632	29·788	48·3	40·6
20	29·935	30·044	30·084	30·154	56·2	43·5	20	29·895	30·034	30·126	30·243	54·0	39·9
21	30·145	30·208	30·214	30·230	49·6	39·0	21	30·279	30·330	30·316	30·330	45·9	38·4
22	30·211	30·169	30·098	30·076	50·0	37·8	22	30·322	30·308	30·273	30·297	50·0	37·2
23	29·929	29·829	29·731	29·681	44·1	32·7	23	30·203	30·116	30·026	29·927	48·1	35·3
24	29·584	29·546	29·522	29·556	49·3	32·0	24	29·800	29·746	29·700	29·679	47·0	35·4
25	29·558	29·616	29·640	29·704	53·6	37·9	25	29·600	29·556	29·498	29·516	43·9	34·9
26	29·715	29·713	29·624	29·571	59·7	34·2	26	29·580	29·627	29·610	29·615	50·8	35·3
27	29·444	29·399	29·373	29·396	58·6	48·0	27	29·558	29·508	29·433	29·457	54·4	42·1
28	29·382	29·390	29·391	29·414	57·2	48·5	28	29·430	29·464	29·433	29·483	46·4	43·6
29	29·401	29·439	29·464	29·552	61·4	48·6	29	29·487	29·541	29·556	29·637	48·1	42·3
30	29·638	29·676	29·650	29·697	59·1	41·8	30	29·635	29·681	29·763	29·860	51·7	40·4

BAROMETER READINGS, &c.

MAY, 1883.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·682	29·715	29·716	29·844	59·3	42·2	1	29·929	29·968	29·957	30·013	55·5	37·7
2	29·854	29·883	29·871	29·881	48·0	39·5	2	30·014	30·013	29·948	29·909	52·2	39·7
3	29·843	29·805	29·775	29·832	51·2	36·2	3	29·850	29·886	29·904	29·960	47·4	38·9
4	29·824	29·836	29·798	29·832	48·0	31·8	4	29·965	29·967	29·978	30·021	47·7	38·8
5	29·827	29·823	29·768	29·842	53·4	32·1	5	30·006	30·002	29·989	30·000	47·8	37·5
6	29·814	29·836	29·803	29·809	64·1	42·4	6	30·066	30·072	29·995	29·963	58·1	33·0
7	29·694	29·665	29·636	29·633	58·4	41·6	7	29·869	29·771	29·694	29·741	54·7	35·9
8	29·592	29·565	29·499	29·479	48·0	39·0	8	29·726	29·723	29·680	29·685	44·3	35·2
9	29·456	29·493	29·517	29·563	47·2	41·4	9	29·635	29·654	29·680	29·710	48·8	36·8
10	29·543	29·596	29·625	29·735	48·0	36·0	10	29·637	29·586	29·524	29·531	49·1	34·9
11	29·786	29·870	29·897	29·925	51·1	37·0	11	29·519	29·538	29·598	29·648	51·0	36·3
12	29·794	29·795	29·853	29·939	57·0	42·2	12	29·526	29·382	29·473	29·452	55·7	38·4
13	——	29·958	29·911	29·870	68·1	51·4	13	29·538	29·510	29·522	29·594	60·4	48·5
14	29·859	29·888	29·908	29·957	61·4	51·4	14	29·634	29·684	29·722	29·810	57·8	47·6
15	29·993	30·057	30·088	30·177	65·0	51·3	15	29·904	30·038	30·110	30·220	60·8	43·3
16	30·216	30·272	30·249	30·333	71·0	50·6	16	30·286	30·349	30·334	30·370	60·7	40·3
17	30·341	30·362	30·304	30·293	65·3	46·0	17	30·328	30·319	30·280	30·296	58·4	38·7
18	30·253	30·240	30·154	30·089	60·3	47·3	18	30·228	30·156	29·997	29·942	55·0	43·9
19	30·004	30·010	29·977	29·992	59·7	49·4	19	29·935	29·941	29·941	29·941	56·8	44·6
20	29·985	30·020	30·026	30·089	58·4	49·0	20	29·945	29·991	29·994	30·031	62·2	42·3
21	30·111	30·161	30·128	30·163	66·2	43·6	21	30·034	30·059	30·036	30·043	62·2	47·1
22	30·161	30·157	30·099	30·129	71·0	42·0	22	29·996	29·990	29·993	30·007	57·1	48·3
23	30·111	30·103	30·066	30·090	74·7	47·7	23	29·971	29·965	29·955	29·939	55·2	47·8
24	30·084	30·076	30·004	30·018	76·0	48·5	24	29·889	29·885	29·857	29·830	62·6	49·9
25	29·988	29·888	29·764	29·683	73·6	49·4	25	29·758	29·710	29·630	29·597	61·3	50·1
26	29·594	29·555	29·597	29·738	58·9	50·0	26	29·614	29·652	29·686	29·769	56·7	41·3
27	29·842	29·948	29·974	30·024	65·0	48·0	27	29·822	29·871	29·859	29·804	59·9	38·3
28	30·025	30·038	30·016	30·028	66·1	43·7	28	29·671	29·666	29·676	29·658	56·0	49·2
29	30·002	29·986	29·993	30·073	65·4	47·3	29	29·630	29·696	29·768	29·832	57·5	47·4
30	30·118	30·170	30·164	30·207	66·5	46·8	30	29·938	30·046	30·081	30·104	48·7	44·2
31	30·212	30·201	30·136	30·120	68·6	44·5	31	30·037	29·988	29·958	29·913	55·2	49·1

JUNE, 1883.

1	30·072	30·016	29·970	30·003	68·6	44·5	1	29·834	29·822	29·810	29·863	60·3	51·8
2	30·026	30·073	30·068	30·143	71·3	47·6	2	29·930	30·031	30·120	30·199	62·0	46·8
3	30·151	30·123	30·076	30·091	69·7	50·1	3	30·234	30·228	30·186	30·186	65·6	45·8
4	30·030	29·965	29·879	29·888	72·2	47·6	4	30·169	30·140	30·056	30·066	65·1	46·0
5	29·829	29·821	29·780	29·826	70·3	47·9	5	30·044	30·013	29·963	29·960	57·0	44·2
6	29·821	29·804	29·751	29·765	66·7	45·0	6	29·908	29·857	29·792	29·800	59·1	45·4
7	29·746	29·738	29·736	29·745	53·9	47·6	7	29·778	29·749	29·713	29·711	57·7	45·1
8	29·745	29·763	29·770	29·827	67·2	47·9	8	29·696	29·682	29·682	29·746	64·3	41·0
9	29·831	29·857	29·840	29·890	68·9	47·1	9	29·777	29·841	29·846	29·924	65·1	47·3
10	29·898	29·926	29·910	29·993	67·3	48·9	10	29·966	30·017	30·033	30·091	60·3	48·8
11	30·032	30·099	30·155	30·232	57·3	47·1	11	30·110	30·157	30·161	30·197	61·1	49·4
12	30·265	30·288	30·254	30·308	71·0	43·7	12	30·154	30·174	30·213	30·252	61·3	49·9
13	30·340	30·366	30·310	30·315	74·6	52·4	13	30·274	30·312	30·285	30·274	63·6	52·9
14	30·265	30·250	30·148	30·083	73·5	53·7	14	30·226	30·184	30·110	30·038	59·8	46·0
15	29·961	29·877	29·758	29·739	60·7	47·6	15	29·940	29·886	29·869	29·874	57·9	41·7
16	29·749	29·797	29·845	29·883	60·6	44·8	16	29·858	29·834	29·786	29·818	58·1	42·5
17	29·884	29·900	29·905	29·948	61·1	41·6	17	29·811	29·814	29·798	29·835	59·9	42·7
18	29·931	29·923	29·878	29·903	63·9	47·8	18	29·841	29·879	29·869	29·878	58·6	44·9
19	29·870	29·886	29·840	29·839	63·7	48·0	19	29·837	29·791	29·747	29·777	57·8	44·9
20	29·805	29·828	29·840	29·872	63·8	49·9	20	29·828	29·951	29·977	30·050	60·4	46·0
21	29·832	29·849	29·839	29·921	63·3	52·0	21	30·035	30·017	29·936	29·931	63·4	43·4
22	29·959	30·004	29·979	29·967	65·9	49·9	22	29·870	29·809	29·747	29·772	58·0	43·7
23	29·968	29·999	29·975	29·985	69·8	52·2	23	29·805	29·825	29·811	29·787	64·4	44·4
24	29·956	29·951	29·884	29·862	72·8	58·6	24	29·775	29·802	29·755	29·770	58·3	52·9
25	29·804	29·796	29·727	29·730	73·6	54·5	25	29·763	29·775	29·741	29·713	64·4	51·1
26	29·708	29·719	29·778	29·847	63·4	52·1	26	29·565	29·410	29·354	29·465	59·1	49·2
27	29·860	29·889	29·869	29·829	64·5	51·2	27	29·528	29·613	29·592	29·539	62·1	49·6
28	29·817	29·888	29·950	30·001	69·0	57·3	28	29·537	29·629	29·689	29·751	66·4	52·1
29	30·004	29·980	29·928	29·918	83·4	54·6	29	29·788	29·831	29·819	29·857	63·5	56·6
30	29·910	29·946	29·976	30·055	78·6	57·7	30	29·891	29·919	29·903	29·921	71·7	56·0

BAROMETER READINGS, &c.

JULY, 1883.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·063	30·083	30·041	30·079	75·4	51·6	1	29·907	29·883	29·867	29·891	67·0	54·1
2	30·057	30·043	29·949	29·919	82·0	54·7	2	29·898	29·897	29·881	29·872	69·6	54·1
3	29·846	29·839	29·834	29·863	76·1	60·0	3	29·817	29·817	29·777	29·799	68·0	57·7
4	29·836	29·794	29·777	29·827	69·5	54·6	4	29·769	29·719	29·631	29·598	61·1	56·0
5	29·840	29·853	29·839	29·870	69·5	52·6	5	29·621	29·663	29·654	29·699	67·0	54·5
6	29·842	29·805	29·762	29·796	73·6	50·4	6	29·673	29·647	29·615	29·621	61·4	51·0
7	29·782	29·838	29·827	29·846	71·8	57·1	7	29·602	29·618	29·632	29·635	66·1	55·7
8	29·843	29·864	29·831	29·796	73·9	57·4	8	29·600	29·676	29·684	29·655	68·4	55·8
9	29·710	29·790	29·844	29·903	72·3	56·8	9	29·559	29·595	29·661	29·741	66·6	51·0
10	29·882	29·876	29·838	29·827	69·7	54·1	10	29·722	29·706	29·660	29·605	66·4	50·8
11	29·739	29·634	29·569	29·584	70·0	56·6	11	29·475	29·336	29·258	29·206	64·1	53·8
12	29·564	29·560	29·478	29·502	66·0	55·7	12	29·160	29·149	29·149	29·222	60·3	53·1
13	29·558	29·649	29·705	29·736	69·6	53·6	13	29·317	29·463	29·536	29·629	63·7	47·5
14	29·721	29·715	29·725	29·760	65·2	52·3	14	29·640	29·669	29·678	29·715	59·5	44·7
15	29·796	29·835	29·856	29·956	61·5	46·6	15	29·745	29·789	29·807	29·869	60·1	46·6
16	30·033	30·122	30·135	30·123	61·4	44·1	16	29·903	29·929	29·899	29·878	58·7	48·2
17	30·062	30·023	29·972	29·927	63·0	52·5	17	29·812	29·731	29·739	29·807	60·1	49·5
18	29·908	29·920	29·884	29·854	63·0	49·6	18	29·826	29·835	29·790	29·754	61·6	46·4
19	29·786	29·761	29·735	29·745	65·3	48·5	19	29·703	29·719	29·695	29·702	62·8	46·1
20	29·724	29·723	29·652	29·613	64·5	47·6	20	29·673	29·664	29·619	29·606	61·9	43·0
21	29·529	29·549	29·560	29·637	60·9	51·9	21	29·583	29·618	29·635	29·655	59·8	48·4
22	29·667	29·758	29·816	29·866	63·5	48·6	22	29·653	29·667	29·644	29·651	60·3	47·1
23	29·831	29·796	29·724	29·703	63·8	48·3	23	29·623	29·624	29·621	29·635	57·3	44·6
24	29·675	29·729	29·776	29·875	64·6	51·7	24	29·651	29·711	29·732	29·760	58·7	49·1
25	29·914	29·951	29·961	30·017	64·8	50·2	25	29·763	29·797	29·858	29·962	63·6	49·7
26	30·033	30·070	30·076	30·128	66·7	50·8	26	30·013	30·071	30·113	30·178	64·4	51·1
27	30·125	30·121	30·104	30·136	62·6	48·8	27	30·211	30·218	30·189	30·190	70·2	49·9
28	30·110	30·093	30·051	30·015	71·3	52·7	28	30·139	30·079	30·008	29·964	68 1	45·8
29	29·961	29·899	29·811	29·726	69·7	47·9	29	29·859	29·785	29·663	29·623	67·0	46·4
30	29·612	29·585	29·576	29·606	67·3	52·7	30	29·594	29·586	29·563	29·583	65·4	49·0
31	29·618	29·691	29·735	29·823	71·2	52·7	31	29·609	29·641	29·671	29·729	62·3	47·1

AUGUST, 1883.

1	29·901	29·989	30·033	30·106	66·5	54·1	1	29·766	29·835	29·898	29·961	63·6	51·0
2	30·121	30·171	30·159	30·180	69·5	52·6	2	30·000	30·067	30·101	30·144	64·2	50·0
3	30·182	30·210	30·173	30·191	69·7	55·0	3	30·150	30·172	30·157	30·155	65·7	48·1
4	30·186	30·214	30·174	30·160	72·7	52·7	4	30·188	30·061	30·011	30·005	62·3	52·8
5	30·109	30·095	30·050	30·031	67·8	57·7	5	29·991	29·992	29·970	29·963	63·1	51·5
6	29·963	29·921	29·855	29·842	68·0	58·0	6	29·894	29·869	29·821	29·819	64·0	50·4
7	29·847	29·929	29·968	30·028	69·9	54·7	7	29·809	29·856	29·869	29·858	62·3	49·8
8	29·980	29·848	29·688	29·584	60·9	51·2	8	29·584	29·246	29·261	29·287	60·3	48·8
9	29·555	29·632	29·593	29·608	65·7	52·5	9	29·210	29·142	29·073	29·068	56·8	46·9
10	29·583	29·582	29·579	29·688	65·6	50·2	10	29·104	29·185	29·321	29·461	61·5	49·0
11	29·757	29·865	29·936	30·047	65·5	51·3	11	29·569	29·606	29·807	29·896	59·8	49·4
12	30·099	30·150	30·129	30·098	70·4	46·0	12	29·948	29·995	29·973	29·938	63·1	46·2
13	29·996	29·938	29·865	29·813	78·6	53·9	13	29·752	29·681	29·618	29·480	61·6	50·7
14	29·774	29·766	29·703	29·660	72·6	59·5	14	29·473	29·404	29·302	29·238	63·4	54·8
15	29·621	29·655	29·701	29·795	66·7	56·8	15	29·259	29·369	29·533	29·715	64·0	48·0
16	29·883	30·009	30·053	30·089	64·8	50·0	16	29·819	29·909	29·926	29·925	59·2	45·8
17	30·069	30·057	30·020	30·025	68·6	47·7	17	29·855	29·826	29·806	29·887	61·1	49·7
18	30·051	30·147	30·140	30·205	75·8	54·9	18	29·939	29·992	29·981	30·052	60·9	49·8
19	30·224	30·262	30·193	30·201	75·6	51·3	19	30·107	30·169	30·158	30·128	61·7	52·3
20	30·155	30·124	30·049	30·089	77·8	48·5	20	30·015	29·935	29·870	29·917	63·5	48·8
21	30·098	30·150	30·107	30·134	79·2	58·5	21	30·006	30·102	30·120	30·132	60·2	52·1
22	30·123	30·135	30·144	30·205	74·0	58·2	22	30·109	30·129	30·133	30·185	62·8	49·7
23	30·229	30·246	30·217	30·257	72·1	51·9	23	30·189	30·207	30·194	30·210	65·4	49·1
24	30·244	30·242	30·186	30·206	73·0	47·2	24	30·175	30·186	30·157	30·159	66·9	53·9
25	30·169	30·162	30·083	30·103	74·8	49·6	25	30·093	30·064	30·015	29·995	66·7	49·0
26	30·086	30·104	30·076	30·097	76·1	50·5	26	29·926	29·934	29·910	29·860	62·0	54·2
27	30·047	30·020	29·953	29·977	75·1	53·7	27	29·736	29·722	29·744	29·774	62·4	53·7
28	29·939	29·986	29·916	29·886	73·7	59·1	28	29·800	29·807	29·645	29·510	58·0	51·5
29	29·787	29·806	29·851	29·901	70·5	58·1	29	29·541	29·708	29·776	29·794	62·3	49·1
30	29·887	29·896	29·838	29·817	69·8	56·6	30	29·712	29·578	29·523	29·580	61·9	49·7
31	29·782	29·753	29·643	29·577	63·3	54·9	31	29·564	29·557	29·521	29·489	61·4	50·9

BAROMETER READINGS, &c.

SEPTEMBER, 1883.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·554	29·527	29·388	29·152	64·9	52·1	1	29·383	29·353	29·255	29·124	62·0	49·9
2	28·908	28·830	28·741	28·980	62·5	57·5	2	28·954	28·834	28·798	28·875	60·7	51·3
3	29·201	29·387	29·474	29·569	65·4	52·9	3	28·963	29·060	29·174	29·339	64·5	51·8
4	29·629	29·705	29·755	29·784	62·8	47·7	4	29·435	29·518	29·567	29·653	57·0	44·0
5	29·722	29·805	29·869	30·023	62·3	44·6	5	29·735	29·861	29·923	29·912	60·4	43·7
6	30·026	29·971	29·871	29·869	56·7	42·1	6	29·763	29·557	29·556	29·529	57·4	46·5
7	29·559	29·863	29·873	29·911	61·3	47·5	7	29·467	29·497	29·581	29·627	58·6	49·0
8	29·875	29·832	29·947	30·083	64·2	46·6	8	29·634	29·750	29·895	29·992	59·1	46·3
9	30·122	30·137	30·056	30·031	67·0	40·0	9	29·982	29·961	29·912	29·855	59·1	46·1
10	29·939	29·929	29·895	29·898	65·7	51·7	10	29·779	29·777	29·837	29·965	61·4	45·1
11	29·893	29·978	30·052	30·120	59·6	54·8	11	30·065	30·158	30·157	30·214	58·0	41·8
12	30·099	30·147	30·119	30·184	69·2	51·5	12	30·194	30·200	30·165	30·196	60·4	37·1
13	30·180	30·235	30·165	30·174	66·5	50·6	13	30·194	30·238	30·193	30·234	60·5	46·0
14	30·122	30·092	29·990	29·967	69·1	53·1	14	30·195	30·179	30·097	30·109	63·3	51·5
15	29·929	29·931	29·939	30·014	67·4	51·6	15	30·035	29·985	29·939	29·963	60·8	51·2
16	30·060	30·134	30·130	30·178	69·7	49·7	16	29·980	30·039	30·059	30·111	65·0	53·1
17	30·172	30·186	30·143	30·181	72·8	47·6	17	30·118	30·147	30·113	30·131	59·7	51·6
18	30·170	30·168	30·131	30·162	73·2	48·9	18	30·136	30·155	30·118	30·131	61·1	49·3
19	30·124	30·101	29·981	29·908	73·6	54·5	19	30·089	30·035	29·943	29·890	57·0	31·8
20	29·789	29·712	29·685	29·717	64·3	53·6	20	29·815	29·813	29·779	29·779	54·6	47·2
21	29·689	29·696	29·695	29·689	64·6	51·2	21	29·749	29·774	29·747	29·743	53·5	47·0
22	29·617	29·659	29·736	29·887	61·0	51·1	22	29·696	29·719	29·731	29·862	59·2	47·8
23	29·986	30·063	30·015	29·983	65·0	44·1	23	29·925	29·960	29·891	29·810	55·8	43·8
24	29·804	29·624	29·648	29·708	67·2	55·7	24	29·619	29·456	29·393	29·415	56·2	47·4
25	29·724	29·788	29·813	29·876	65·8	54·9	25	29·415	29·509	29·578	29·653	60·9	51·7
26	29·759	29·640	29·673	29·703	66·6	54·6	26	29·535	29·214	28·817	29·023	58·1	50·8
27	29·668	29·636	29·594	29·659	62·8	51·0	27	29·151	29·242	29·310	29·413	58·8	50·7
28	29·657	29·675	29·558	29·337	62·0	49·8	28	29·471	29·462	29·366	29·282	57·2	47·9
29	29·252	29·252	29·219	29·213	57·6	47·9	29	29·251	29·383	29·453	29·565	58·7	48·2
30	29·226	29·316	29·415	29·541	55·5	46·1	30	29·627	29·698	29·715	29·796	52·0	43·7

OCTOBER, 1883.

1	29·569	29·723	29·786	29·852	54·0	44·8	1	29·829	29·891	29·921	29·984	50·5	38·3
2	29·893	29·968	29·960	29·960	52·8	41·3	2	29·948	29·942	29·841	29·755	51·7	38·8
3	29·795	29·636	29·410	29·421	49·5	42·1	3	29·569	29·494	29·514	29·644	51·7	39·9
4	29·358	29·491	29·693	29·906	53·8	41·3	4	29·738	29·866	29·919	30·015	54·4	39·1
5	29·994	30·096	30·062	30·070	54·8	45·3	5	30·021	30·057	30·066	30·108	53·6	38·7
6	30·076	30·194	30·259	30·379	56·2	39·6	6	30·177	30·278	30·285	30·287	53·8	37·6
7	30·406	30·436	30·400	30·409	55·3	39·7	7	30·233	30·260	30·297	30·345	62·5	46·9
8	30·447	30·507	30·478	30·476	60·7	51·5	8	30·365	30·417	30·379	30·318	57·0	51·4
9	30·420	30·384	30·269	30·196	59·0	46·3	9	30·191	30·121	30·095	30·067	59·0	52·1
10	30·098	30·047	29·925	29·897	59·6	43·9	10	30·050	30·023	29·928	29·884	52·7	46·0
11	29·829	29·851	29·852	29·929	58·8	46·7	11	29·830	29·866	29·899	29·959	53·6	38·9
12	29·985	30·050	30·023	30·055	56·2	42·5	12	29·991	30·013	29·925	29·882	52·8	38·0
13	30·042	30·046	29·998	30·023	60·0	42·5	13	29·784	29·725	29·645	29·646	56·5	49·2
14	29·955	29·897	29·790	29·678	62·6	47·0	14	29·572	29·511	29·438	29·486	57·1	48·9
15	29·663	29·749	29·721	29·568	57·3	48·9	15	29·485	29·486	29·362	29·089	54·1	43·9
16	29·386	29·381	29·416	29·460	59·5	50·0	16	28·946	28·812	28·846	28·972	50·9	44·2
17	29·289	29·480	29·518	29·532	58·0	47·4	17	28·934	29·076	29·098	29·201	48·8	40·2
18	29·787	29·958	30·042	30·104	54·5	43·3	18	29·313	29·472	29·559	29·616	46·7	39·0
19	30·027	29·897	29·507	29·740	56·8	47·5	19	29·560	29·519	29·426	29·425	48·1	40·4
20	29·718	29·709	29·652	29·707	50·7	38·7	20	29·385	29·382	29·405	29·484	49·3	39·0
21	29·737	29·819	29·829	29·897	54·1	38·4	21	29·574	29·708	29·800	29·892	49·8	35·9
22	29·927	30·010	30·005	29·997	48·3	38·6	22	29·887	29·830	29·637	29·436	48·5	32·1
23	29·834	29·717	29·693	29·745	57·4	39·8	23	29·330	29·367	29·389	29·363	49·3	41·0
24	29·734	29·812	29·728	29·731	58·1	43·1	24	29·463	29·497	29·400	29·210	55·0	40·2
25	29·728	29·767	29·830	29·947	60·2	55·3	25	29·120	29·381	29·514	29·693	55·0	42·8
26	29·970	30·005	29·959	29·948	59·3	53·1	26	29·785	29·863	29·771	29·631	52·6	41·1
27	29·942	30·042	30·078	30·169	60·6	43·1	27	29·650	29·833	29·973	30·071	53·1	41·8
28	30·169	30·207	30·147	30·134	59·6	43·0	28	30·061	30·064	30·028	30·063	55·6	40·0
29	30·129	30·202	30·231	30·322	54·8	50·1	29	30·079	30·188	30·241	30·321	53·0	48·4
30	——	30·410	30·396	30·401	52·8	47·1	30	30·343	30·375	30·337	30·334	54·2	42·2
31	30·324	30·298	30·186	30·197	52·2	48·2	31	30·245	30·216	30·136	30·168	50·2	47·5

BAROMETER READINGS, &c.

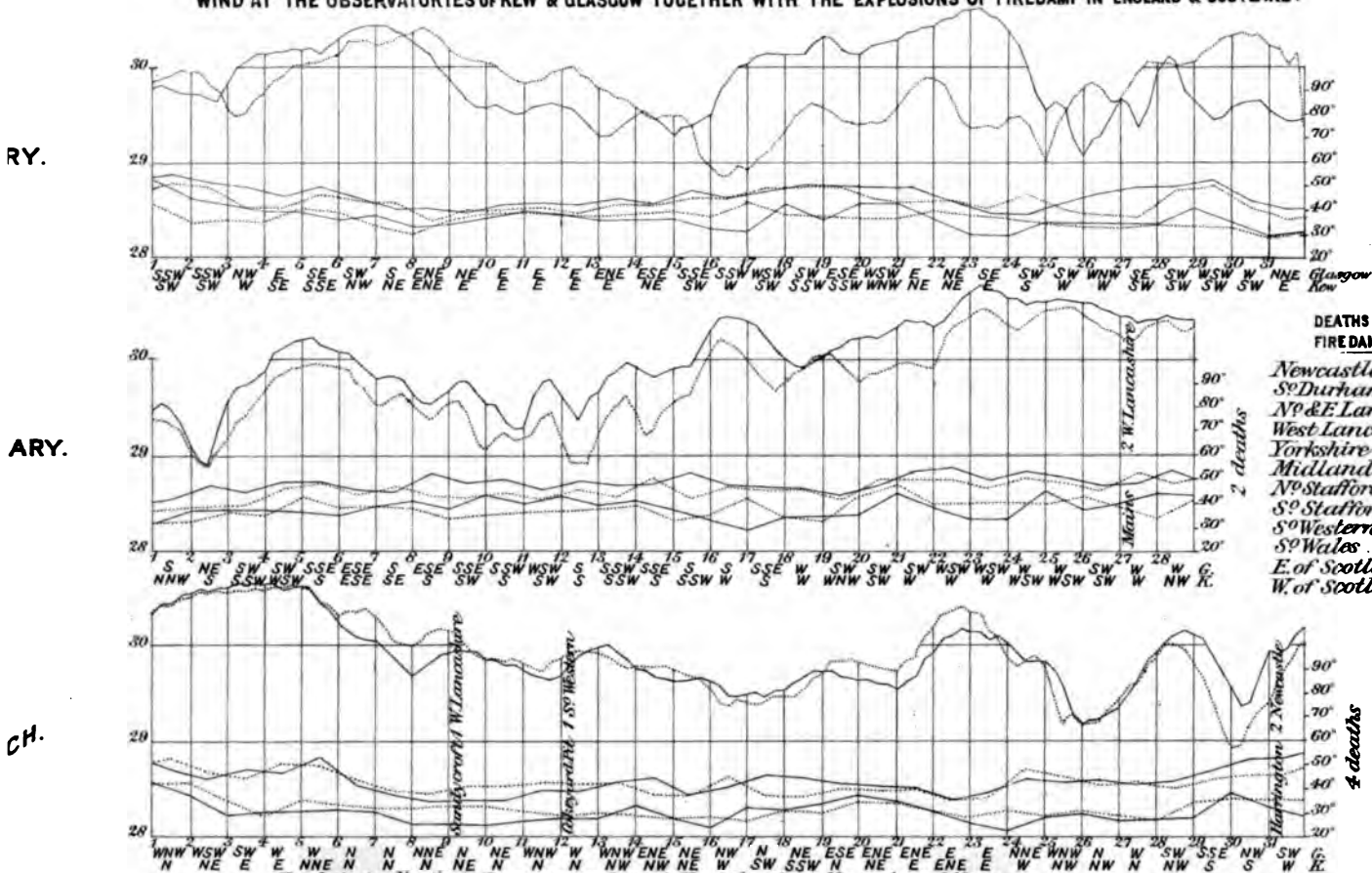
NOVEMBER, 1883.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·190	30·238	30·221	30·235	50·2	46·6	1	30·163	30·217	30·212	30·192	50·9	47·0
2	30·172	30·149	30·044	30·019	48·2	45·0	2	30·087	30·016	29·903	29·846	49·9	47·0
3	29·978	30·018	30·031	30·070	48·3	43·4	3	29·829	29·889	29·909	29·827	52·6	42·8
4	30·016	29·816	29·525	29·615	51·7	37·1	4	29·454	29·262	29·229	29·165	49·2	39·5
5	29·622	29·653	29·571	29·342	48·6	39·4	5	29·170	29·287	29·263	29·164	48·4	40·0
6	28·987	28·945	29·223	29·440	56·0	38·2	6	29·097	29·164	29·273	29·371	45·4	33·5
7	29·515	29·571	29·540	29·567	46·3	32·0	7	29·401	29·445	29·437	29·445	39·2	32·9
8	29·616	29·705	29·732	29·679	49·5	38·6	8	29·439	29·471	29·413	29·312	45·4	37·0
9	29·641	29·662	29·652	29·687	52·9	40·2	9	29·288	29·380	29·359	29·336	45·0	33·0
10	29·610	29·625	29·697	29·739	45·4	37·8	10	29·347	29·269	29·371	29·609	46·2	33·2
11	29·782	29·813	29·738	29·677	46·9	37·0	11	29·681	29·714	29·669	29·687	42·5	30·2
12	29·686	29·784	29·838	29·921	45·4	31·0	12	29·718	29·808	29·860	29·973	34·1	25·1
13	29·948	30·023	30·077	30·162	45·5	29·7	13	30·034	30·113	30·145	30·209	37·9	25·3
14	30·183	30·191	30·127	30·129	42·6	30·0	14	30·206	30·189	30·168	30·132	38·1	24·5
15	30·063	30·020	29·928	29·826	42·3	29·3	15	30·027	29·910	29·750	29·660	41·0	33·7
16	29·677	29·646	29·735	29·845	49·2	38·2	16	29·614	29·610	29·598	29·586	40·3	35·0
17	29·852	29·770	29·604	29·760	48·9	31·6	17	29·437	29·365	29·465	29·649	43·6	35·1
18	29·870	29·975	29·931	29·849	49·8	33·0	18	29·736	29·634	29·491	29·549	47·8	31·9
19	29·899	29·915	29·965	29·970	50·5	39·6	19	29·511	29·471	29·483	29·481	42·7	33·3
20	29·941	29·897	29·950	30·048	47·8	39·2	20	29·375	29·419	29·511	29·674	42·1	34·0
21	30·064	29·885	29·913	29·964	52·6	37·7	21	29·555	29·440	29·496	29·454	42·6	35·0
22	29·911	29·802	29·698	29·669	49·5	40·9	22	29·381	29·300	29·290	29·375	40·6	36·3
23	29·611	29·761	29·836	29·830	45·8	34·9	23	29·441	29·511	29·488	29·322	43·0	36·7
24	29·626	29·496	29·493	29·364	52·0	38·2	24	29·063	29·066	29·086	28·912	44·8	38·1
25	29·166	29·066	29·034	29·052	54·6	48·0	25	28·613	28·519	28·587	28·643	48·7	42·7
26	29·046	29·112	29·281	29·520	50·9	38·7	26	28·689	28·778	28·870	29·106	45·1	39·8
27	29·712	29·932	30·035	30·119	48·8	36·4	27	29·336	29·575	29·663	29·650	51·7	42·0
28	30·179	30·287	30·315	30·385	55·3	38·3	28	29·717	29·813	29·893	29·965	54·6	51·4
29	30·360	30·358	30·297	30·286	48·4	36·0	29	30·009	29·975	29·946	29·938	54·6	49·8
30	30·262	30·250	30·102	30·011	50·6	41·0	30	29·988	30·066	30·083	30·158	52·2	40·9

DECEMBER, 1883.

1	30·106	30·238	30·328	30·373	45·4	37·0	1	30·253	30·319	30·255	30·139	46·0	37·3
2	30·337	30·317	30·261	30·240	44·9	38·7	2	30·150	30·118	30·071	29·954	45·3	39·6
3	30·100	29·877	29·650	29·580	54·0	39·3	3	29·726	29·561	29·470	29·519	45·4	35·5
4	29·595	29·708	29·799	29·985	47·8	36·5	4	29·623	29·834	29·973	30·119	43·0	34·6
5	30·075	30·108	30·102	30·076	40·2	32·9	5	30·182	30·212	30·185	30·216	39·8	31·2
6	30·067	30·078	30·242	30·333	34·8	29·4	6	30·242	30·249	30·446	30·538	38·9	27·9
7	30·448	30·539	30·534	30·552	35·6	31·5	7	30·548	30·550	30·482	30·444	38·3	27·6
8	30·504	30·482	30·404	30·386	35·4	31·6	8	30·363	30·294	30·210	30·113	43·2	38·3
9	30·333	30·292	30·189	30·131	40·0	32·6	9	29·959	29·889	29·889	29·874	45·2	37·7
10	30·045	29·975	29·844	29·644	47·2	39·9	10	29·737	29·529	29·332	29·212	45·7	36·9
11	29·423	29·665	29·806	29·647	49·2	40·5	11	29·259	29·466	29·419	28·749	48·8	36·5
12	29·541	29·769	29·939	30·073	51·6	39·5	12	29·202	29·571	29·747	29·759	45·1	36·0
13	29·983	29·915	29·848	29·854	54·0	39·7	13	29·484	29·401	29·445	29·423	51·9	39·2
14	29·776	29·631	29·668	29·789	53·8	40·3	14	29·344	29·315	29·293	29·303	45·5	35·5
15	29·837	29·841	29·684	29·494	45·8	38·2	15	29·466	29·453	29·307	29·422	39·8	33·9
16	29·488	29·724	29·846	30·063	40·0	34·6	16	29·671	29·958	30·181	30·353	39·0	33·1
17	30·182	30·335	30·372	30·417	38·9	34·9	17	30·435	30·516	30·492	30·419	38·1	33·2
18	30·416	30·417	30·311	30·265	40·3	33·7	18	30·304	30·215	30·113	30·195	47·4	37·8
19	30·269	30·334	30·268	30·194	44·1	37·2	19	30·179	30·165	30·082	29·865	48·1	41·0
20	30·070	30·026	29·960	29·926	46·8	36·0	20	29·771	29·769	29·688	29·680	48·8	39·3
21	29·849	29·877	29·879	29·906	48·2	40·4	21	29·631	29·493	29·470	29·494	46·2	38·0
22	29·913	29·944	29·916	29·913	49·5	42·1	22	29·419	29·433	29·319	29·478	48·0	36·9
23	29·995	30·240	30·363	30·453	49·4	32·4	23	29·763	30·055	30·169	30·169	40·7	34·3
24	30·468	30·498	30·505	30·537	47·5	32·6	24	30·127	30·183	30·261	30·330	49·6	41·0
25	30·533	30·566	30·544	30·557	44·9	40·0	25	30·372	30·438	30·425	30·439	49·6	43·9
26	30·524	30·546	30·496	30·466	41·9	36·9	26	30·403	30·418	30·402	30·407	45·9	43·6
27	30·422	30·407	30·342	30·332	39·1	35·6	27	30·356	30·310	30·231	30·197	43·7	39·9
28	30·303	30·304	30·281	30·281	42·6	38·8	28	30·142	30·135	30·095	30·096	49·0	42·0
29	30·253	30·250	30·199	30·209	41·3	38·8	29	30·074	30·069	30·035	30·098	49·8	43·0
30	30·245	30·341	30·361	30·434	39·1	36·5	30	30·239	30·399	30·457	30·506	43·0	35·9
31	30·448	30·496	30·427	30·384	37·9	35·8	31	30·530	30·551	30·512	30·485	38·1	34·7

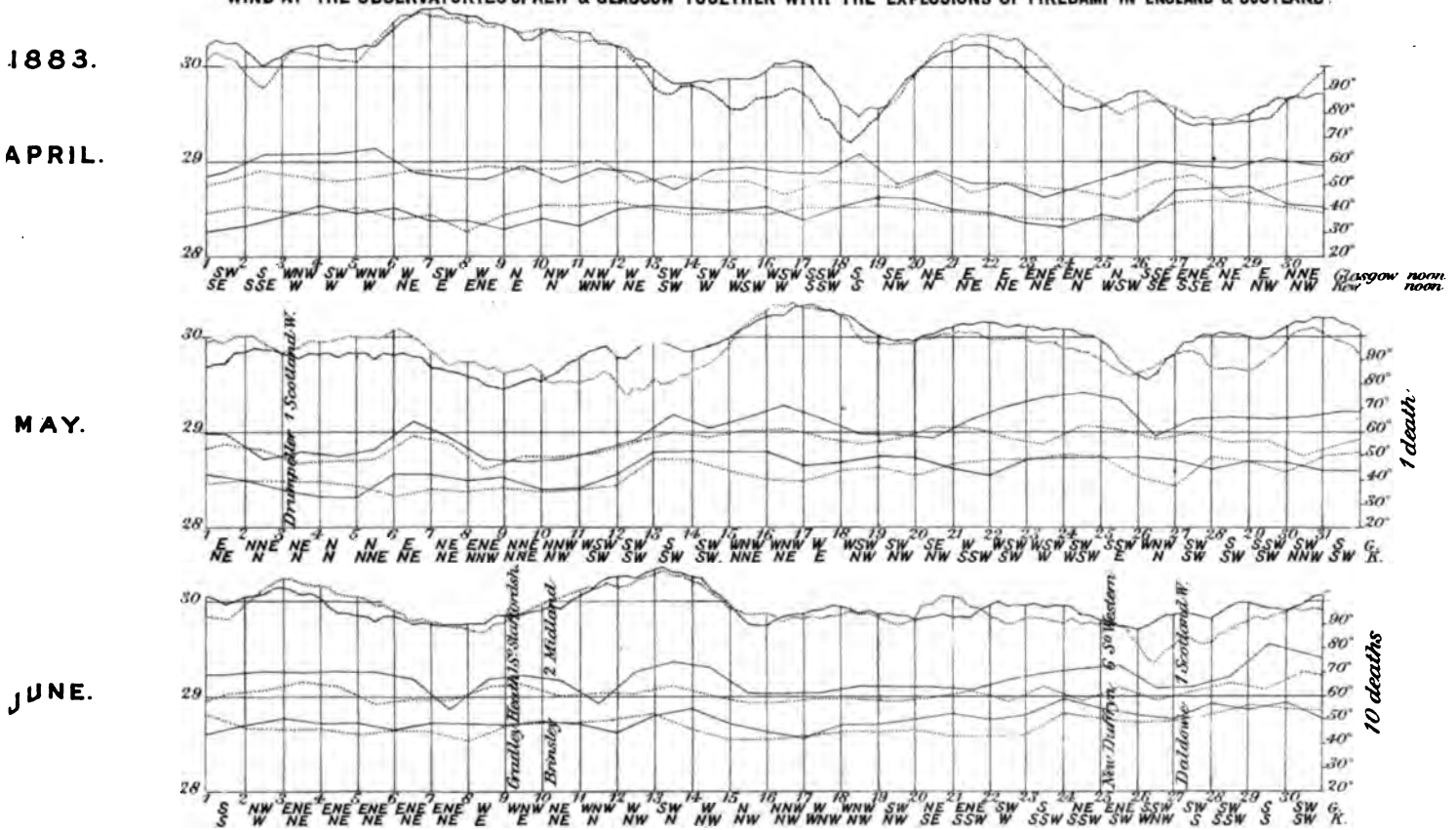
DIAGRAMS SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.



DEATHS FROM EXPLOSIONS OF FIREDAMP DURING THE YEAR 1883

Newcastle	2	deaths
Sº Durham	0	"
Nº & E. Lancashire	74	"
West Lancashire	3	"
Yorkshire	20	"
Midland	2	"
Nº Staffordshire	9	"
Sº Staffordshire	2	"
Sº Western	9	"
Sº Wales	9	"
E. of Scotland	1	"
W. of Scotland	3	"
	134	

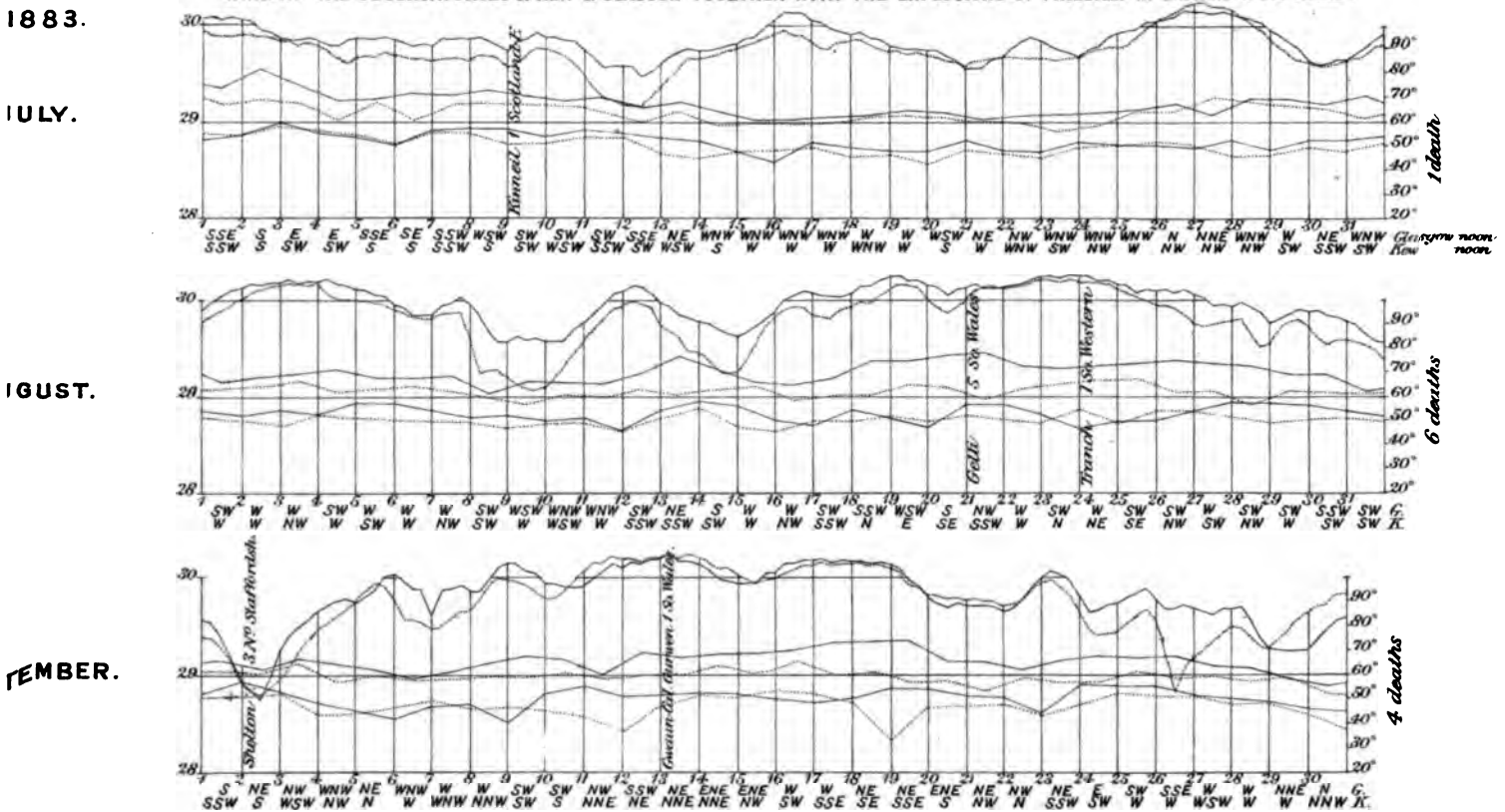
DIAGRAMS SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.



The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 p.m. & 10 a.m.

DIAGRAMS SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.

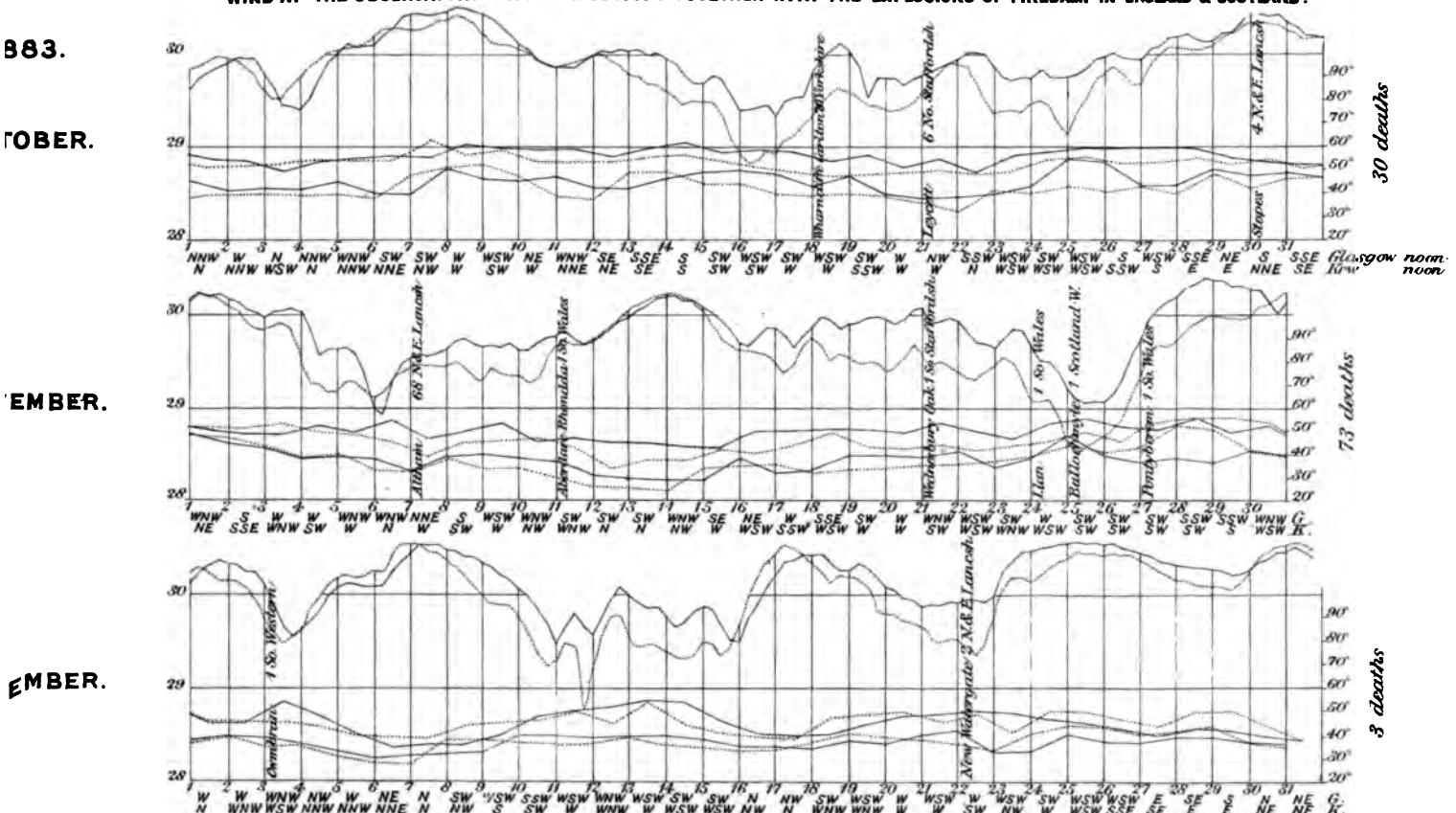
1883.



The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 p.m. & 10 a.m.
Kew lines are firm, Glasgow are dotted,
The figures attached to the districts shew the Number of deaths caused by the explosions.

Amd. Read, Newcastle

DIAGRAMS SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.



NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

ABSTRACTS OF FOREIGN PAPERS.

THE COOLING OF THE WATER OF CONDENSATION BY ARTIFICIAL VENTILATION.

Ueber Abkühlung des Condensationswassers durch künstlichen Luftwechsel. By PROFESSOR WELLNER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen, Vol. XXXI., Part* 12, *pp.* 157–160.

Professor Wellner treats especially of a new method of cooling the warm water from the air-pump by evaporation helped by artificial ventilation, brought about by ventilators, so that the greater part of it can be used over and over again for condensing.

If D be the weight of the steam which finds its way to the condenser from the steam engine per hour, W the weight of injection or water of condensation used per hour, t and t_o = the temperature of the steam and the injection water before entering the condenser, t' = the temperature of the resulting mixture after condensation, then the heat which must come from the steam D to condense it to water of t' temperature, when the specific heat of water for the temperatures under consideration is taken to be = 1, is—

$$D\,(606{\cdot}5 + 0{\cdot}305\,t - t');$$

and the heat acquired by the injection water is—

$$W\,(t' - t_o).$$

From which $$\frac{W}{D} = \frac{606{\cdot}5 + 0{\cdot}305\,t - t'}{t' - t_o} \quad . \quad . \quad . \quad . \quad . \quad (1);$$

and $$t' = \frac{606{\cdot}5 + 0{\cdot}305\,t + \frac{W}{D} - t_o}{\frac{W}{D} + 1} \quad . \quad . \quad . \quad . \quad (2).$$

The water delivered by the air-pump W + D having the high temperature t', must be so far cooled by air, that a quantity of water W of the lower temperature t_o arises to be used again as injection water. The quantity of heat which must be absorbed is—

$$(W + D)\,(t' - t_o) \text{ is from (1).}$$

$$D\,(606{\cdot}5 + 0{\cdot}305\,t - t_o) \quad . \quad . \quad . \quad . \quad (3).$$

This considerable quantity of heat in the water is not to be detracted by mixture or circulation with colder air, but by changing the condition of the water, that is changing the drop-forming water into spray, whereby relatively a very large amount of latent heat is absorbed, bringing about a rapid cooling. The cooling apparatus

devised by the author consists of a slightly inclined quadratic iron pipe of a large area. In the same a number of cloths are stretched vertically side by side, down which the water from the air-pump is made to trickle, while air is blown horizontally through the cloths.

The calculation arriving at quantity of air necessary for the operation is based on the condition that the area of water subjugated to the air is so large that the air, after passing in the cooling apparatus is thoroughly saturated with vapour.

Let $t\,e$ and $T\,e$ = the relative and absolute temperature of the air entering the apparatus.

$t\,a = \frac{t' + t_o}{2}$ and $T\,a$, the same of the air coming from the apparatus.

$V\,e$ and $V\,a$, the volume in cm. of the air on entering and leaving.

$S\,e$ and $S\,a$, the maximum pressure of the water vapour in mm. of mercury for $t\,e$ and $t\,a$.

$\gamma = 1{\cdot}293$, the weight of 1 cm. of dry air at 0° C. and normal barometrical pressure.

$\delta = 0{\cdot}623$, the constant density of the steam at a low pressure with regard to the atmospheric air.

Then the weight of water vapour entering the apparatus is (taking the most unfavourable condition, the almost thorough saturation of the incoming air)—

$$D'\,e = V\,e\,\delta\,\gamma\,\frac{S\,e}{760}\,\frac{273}{T\,e}$$

and the same in leaving—

$$D'\,a = V\,a\,\delta\,\gamma\,\frac{S\,a}{760}\,\frac{273}{T\,a}.$$

As the pressure of the air remains the same throughout—

$$\frac{V\,a}{T\,a} = \frac{V\,e}{T\,e}, \text{ and } D' = D = 0{\cdot}289\,\frac{V\,e}{T\,e}\,(S\,a - S\,e)$$

from which

$$V\,e = 3{\cdot}46\,\frac{D'\,T\,e}{S\,a - S\,e} = 3{\cdot}46\,D'\,\frac{273 + t\,e}{S\,a - S\,e} = 3{\cdot}46\,D\,\frac{273 + t\,e}{S\,a - S\,e} \quad . \quad . \quad (4).$$

The average value of

$$t\,e = 18^\circ \text{ and } t\,a = \frac{t' + 6^o}{2} = 34^\circ,$$

which, according to Regnault, is equal to

$$15{\cdot}36 \text{ mm.} = S\,e \text{ and } 39{\cdot}56 \text{ mm.} = S\,a,$$

so that $\quad V\,e = 41{\cdot}6\,D \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$

that is for every kilogramme of steam used by the engine the quantity of air required in the most unfavourable condition—when the air to be used is nearly saturated with moisture—41·6 cm. of air are required to be blown through the cooling apparatus in order to evaporate therein one kilogramme of spray.

As velocity and not pressure of the air is of importance, Professor Wellner estimates that for 1 *e* of power used 50 cm. of air are requisite, which gives in the most unfavourable situation, one-sixth of the working power as necessary for the ventilators used in the cooling apparatus. To show that there is a saving, although the power required is great, calculations shown in the paper give the percentage of saving in power by the apparatus to be equal to 35, and after deducting the power required for the ventilator in the most unfavourable case put down at 22½ per cent., gives a net gain of 12½ per cent.

C. Z. B.

THE PHYSICAL AND MORAL CONDITION OF THE MEN EMPLOYED IN LARGE ESTABLISHMENTS.

Étude sur la Situation Physique et Morale des Ouvriers des Grands Chantiers. Par M. H. DE LAGRENÉ. *Annales des Ponts et Chaussées, Ser 6, Vol. V.,* 1883, *pp.* 315–345.

The author considers that employers of labour, on interested as well as on moral grounds, should make themselves thoroughly acquainted with their workmen, and should exercise a certain amount of fatherly care over them. In order to do this a master must know what his men as a body think and feel, how they occupy their spare time, what interests they have beyond their work, etc. He has made such observations upon his own men, the results of which are given in this paper.

Chapter I. treats of the recruiting grounds for the different classes of workmen, the system of engagement, hours of work, hours of idleness, food, lodging, clothing, medical attendance, wages, and savings.

In Chapter II. the earnings and expenditure of individual men, one taken from each class, are given and discussed. J. H. M.

THE LEBLANC AND LOISEAU SAFETY GEAR.

Note sur les appareils de sécurité Leblanc et Loiseau. Par M. BROSSARD DE CORBIGNY, *ingénieur en chef des mines. Annales des Mines, Mémoires, Sér.* 8, *Tome II.,* 1882, *pp.* 353–360, *one folding plate.*

This invention of MM. Leblanc and Loiseau is intended to show the position of a train upon the line, and is automatic, being put into action by the train itself. A rocking lever is placed outside, and at right angles to the rails. The end of this lever next the line is furnished with a pedal so placed as to almost touch the rail, and to rise about an inch above it. The other end is attached to a pair of bellows, which it keeps closed by its weight. The bellows are furnished with a small hole for the exit of the air, the size of which can be regulated. The felloe of the first wheel of the train strikes the pedal, depresses the lever, and opens the bellows. Air rushes into the bellows, but can only escape again very slowly. The lever therefore can only rise slowly, and the apparatus is not subjected to the wear and tear which would be produced by a blow from each wheel of the train.

By means of electricity the passage of a train over the pedal is made to ring a bell, or make any other signal that may be required. The apparatus has been in use at Tours during 1881–82, and at other places in France, and has been found to work satisfactorily. J. H. M.

BOILER EXPLOSIONS.

Bulletin des accidents arrivés dans l'emploi des appareils a vapeur pendant l'année 1881. *Annales des Mines, Mémoires, Sér.* 8, *Tome II.,* 1882, *pp.* 468–476.

This paper consists of a list of accidents, twenty-nine in number. The following particulars are given of each:—Date, nature, and situation of the establishment; nature, shape, and size of the boiler; circumstances of the accident; consequences; and presumed cause of the accident. J. H. M.

SPANISH IMPORTS AND EXPORTS, 1882.

Importaciones y Exportaciones de España durante el Año 1882. *Revista Minera y Metalúrgica, Sér. C., Vol. I,* 1883, *pp.* 161, 162.

IMPORTS.

	Quantity.		Value.		Duty.	
	1881.	1882.	1881.	1882.	1881.	1882.
	Tons.	Tons.	£	£	£	£
Coal and coke	982,458	1,108,081	913,397	950,558	98,231	110,808
Tar, asphalt, etc.	20,515	22,929	147,711	165,095	3,364	3,760
Raw petroleum	47,270	34,946	340,342	251,613	7,752	5,731
Refined do.	1,895	445	30,097	5,636	4,168	967
Glass	4,177	4,718	145,984	161,699	34,572	36,717
Steel	1,163	1,430	5,101	6,247	1,567	1,889
Iron and ironwork	112,970	113,319	1,016,386	1,084,109	328,809	336,588
Tin plate	3,471	3,338	88,189	87,244	28,906	27,679
Copper wire (alambre) ...	5,929	7,022	108,838	130,026	18,149	20,640
Copper	643	830	53,285	69,033	10,892	13,606
Common salt	3,109	2,724	2,487	2,179	885	846
Machinery	22,377	25,811	1,134,770	1,317,309	58,430	65,238

EXPORTS.

	Quantity.		Value.	
	1881.	1882.	1881.	1882.
	Tons.	Tons.	£	£
MINERALS—				
Zinc ore	30,604	25,832	63,193	51,664
Copper ore	452,475	571,442	1,294,993	1,600,037
Iron ore	3,137,063	4,021,761	1,584,765	2,413,056
Common salt	335,283	223,830	268,226	178,784
Others	70,327	70,094	221,486	246,673
METALS—				
Quicksilver	1,779	1,167	391,381	232,456
Copper (en torales) ...	17,710	22,708	688,312	882,591
Iron and ironwork ...	37,903	40,116	141,173	142,888
Lead in pigs	105,809	116,132	2,109,934	2,146,004

J. H. M.

ROLLING STOCK ON FRENCH RAILWAYS.

Matériel roulant des chemins de fer français. Annales des Ponts et Chaussées. Mémoires, Sér. 6, *Tome VI.,* 1883, *p.* 85.

The Minister of Public Works has just published the following statistics of the quantity of rolling stock on the whole of the French railways:—

Locomotives—2,826 passenger; 4,067 goods; total, 6,893.

Carriages—3,208 first-class; 5,315 second class; 6,909 third class; total, 15,432.

Trucks—182,089 of all kinds.

J. H. M.

FRENCH RAILWAY STATISTICS, 1882 AND 1881.

Bulletin de l'exploitation, du controle financier et de la statistique des chemins de fer. Division du controle des comptes des compagnies et de la statistique. Résultats comparatifs de l'exploitation des chemins de fer français d'intérêt local (Années 1882 *et* 1881). *Annales des Ponts et Chaussées. Memoires, Sér.* 6, *Tome VI.*, 1883, *p.* 76.

The Minister of Public Works has published a table giving the receipts, expenditure, etc., of the French local railways. The totals for the whole of the lines are, for the following of the items:—

1882—kilometres open, 2,346; receipts per kilometre, 7,744 francs; expenditure per kilometre, 6,497 francs; profit per kilometre, 1,247 francs, which is equal to £80 per mile.

1881—kilometres open, 2,122; receipts per kilometer, 7,827 francs; expenditure per kilometre, 6,190 francs; profit per kilometre, 1,637 francs, which is equal to £105 per mile. J. H. M.

BORING DEEP WELLS BY WATER PRESSURE.

The Scientific American, New Series, Vol. XLIX., 1883, *p.* 144.

Jarvis B. Edson, of North Adams, Mass., has introduced an improvement upon the ordinary method of sinking wells by water pressure, by means of which they can be carried down to depths of 200 or 300 feet, and possibly much further. The improvement consists in placing in the line of pipe, at every two or three lengths, a three-way cock, the side outlet of which is attached to a hose, down which hose water is forced. In this way a continuous stream of water can be kept up. By the old method the stream of water was stopped whilst a fresh length of pipe was being screwed on, allowing sand, gravel, etc., to settle down and jam the pipe. J. H. M.

SINKING OF THE IDA SHAFT AT HOHNDORF.

Die Abtiefung des Ida-Schachtes in Hohndorf. Zeitschrift des Vereines deutscher Ingenieure, Vol. XXVII., 1883, *pp.* 289, 290.

This is a notice of an article which appeared in the sixth volume of the Freiburg Academical Society's magazine, "Glückauf," and gives a short account of the sinking of the Ida Shaft, and a detailed summary of the cost.

The shaft, which was a round one of 14 feet 9 inches in diameter, was lined at the top with masonry, and, to take the guides and other shaft fittings, U-shaped iron rings were spaced at intervals of from 15 feet to 21 feet throughout the depth.

The sinking began in December, 1877, and was continued with hand-winch and hand-pumps to a depth of 33 fathoms, the engines and other plant at bank being in the meantime placed in position. These latter were ready to begin work in May, 1879, and the sinking lasted till the end of April, 1881, progress being made at the rate of 13·7 fathoms per month during the first, and 19 fathoms per month during the second year, the best result obtained in any one month being 23½ fathoms.

The pumps were of sufficient power to deal with 55 gallons of water per minute. The cost of the undertaking was as follows :—

	£	
WAGES.		
For sinking and mason work in the first 33 fathoms	950	
Do. for the rest of distance = 393 fathoms...	5,700	
Fitting of pumping machinery...	95	
Construction of shaft reservoirs for successive tiers of pumps	90	
Miscellaneous	1,165	
	——	£8,000
MATERIALS.		
Masonry, woodwork, and ironwork in shaft	6,500	
Pumping machinery and ropes	2,000	
Coals	640	
Stores	350	
Miscellaneous	160	
	——	9,650
Total cost (exclusive of plant, etc., at bank) ...		£17,650

A. R. L.

THE MEYER STONE-BORING MACHINE.

Die Meyer'sche Gesteinsbohrmaschine. H. LÖLLING. *Zeitschrift des Vereines deutscher Ingenieure, Vol. XXVII.*, 1883, *pp.* 342–346, *Illustrated.*

This is a description of a stone-boring machine made at the Mülheim Engine Works, of Mülheim, on the Ruhr, and much used in the Westphalian coal-field and in other parts of Germany.

The ordinary driving power is steam, but for underground work compressed air is used instead.

Machines are made to work from one to four drills, which can be adjusted to bore in different positions and at different angles simultaneously.

The machine in its simplest form consists of a horizontal spindle working on trunnions between upright columns fixed upon a bed-plate running upon rails. Extending towards the rock face the spindle has a long arm with a small piston working on a pivot at its outer end, so as to be adjustable to different angles. The drill is fixed upon the piston rod, which thus delivers its blow direct, and by means of gearing is made to revolve one-eighth of its circumference after each blow, and to advance gradually into the hole. The speed of the piston is from 500 to 600 strokes per minute, each stroke giving a blow to the drill.

A special form of the machine is made without carriage or spindle for work in confined spaces, to be moved and fixed in position by hand. It consists simply of cylinder and piston, and its weight is about 60 lbs., the diameter of the cylinder being 3¼ inches. A. R. L.

SOME RECENT SYSTEMS OF BOILER FIRING FOR THE PREVENTION OF SMOKE.

Neuere Dampfkesselfeuerungen zur Lösung der Rauchfrage. C. BACH. *Zeitschrift des Vereines deutscher Ingenieure, Vol. XXVII.*, 1883, *pp.* 177–188, *one Plate.*

This is a reprint of a paper read before the Würtemberg Bezirksverein, and contains an examination of the results obtained in the town of Basle, with sixty different boilers fitted with various firing appliances for the prevention of smoke. These are fitted as follows:—

31	with	Tenbrink firing	1
9	„	Double grates by Gebr. Tschann	2
5	„	Schultz firing	3
2	„	Krudewig firing	4
2	„	MacDougall's mechanical stokers	5
2	„	Inclined grates	6
2	„	Scherrer grates	7
2	„	Tier grates	8
1	„	Pasquay grates	9
1	„	Hartmann firing	10
3	„	Shaft firing (for bark and sawdust)	11

Of these Nos. 1, 4, and 7 are favourably mentioned, Nos. 2 and 3 have with careful firing given fair results, and the rest have for the most part been unsatisfactory.

The best results have been given by the Tenbrink system, of which a full description is given. Below one end of the main boiler and in connection with it is placed another in a transverse direction, which is pierced diagonally by one or more large slightly conical tubes, through each of which a grate is fixed at an angle of about 50 degrees, the fire bars being arranged in the form of steps. The fire door is at the upper end. the coal sliding gradually down the incline into the furnace below. Under the fire-door is an air-door, which is so arranged that the amount of air entering the furnace can be regulated at will. Besides the inclined grate, this system has the peculiarity that the hot air is made to pass up the incline, meeting the fresh coals and burning the gas which they contain, so that they reach the lower part of the furnace in the form of coke.

From experiments made with Tenbrink furnaces it appears that from 80 to 85 per cent. of the heat obtainable from the coals is actually transmitted to the water in the boilers, and that they effectually consume their own smoke.

The first cost of furnaces on this principle is said to be considerable, but the saving they effect in fuel is sufficient to counterbalance the extra cost in a comparatively short space of time. A. R. L.

DIAMOND BORING MACHINES.

Der Diamantbohrer für verticale und horizontale Bohrungen. By HERR TECKLENBURG. *Berg- und Hüttenmännische Zeitung*, 1883, *p.* 183.

This is a description of a boring machine made by the American Diamond Rock Boring Company, for boring vertical and horizontal holes underground to a depth of 250 metres (273·4 yards) by steam or compressed air aided by water pressure. Another machine is described by the same author and made by the same firm as above, which is more handy and smaller for boring holes up to 70 metres (76½ yards) in depth.

C. Z. B.

MINING IN THE ORIENTAL DEL URUGUAY REPUBLIC.

Bergmännisches aus der República Oriental del Uruguay. By German Avé Lallemant. *Berg- und Hüttenmännische Zeitung,* 1883, *pp.* 203-204.

Gold mining, the chief mining industry at present of this state, is described, besides lead, copper, silver, and zinc mining, together with the geological features of the country, and description of some of the existing mines, with their respective outputs.

C. Z. B.

THE ANALYSIS OF EXPLOSIVES.

Ueber die Analyse der Sprengstoffe. By Dr. W. Hampe. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im Preussischen Staate. Vol. XXXI. B., pp.* 107-133.

Ordinary dynamite contains 25 per cent. of infusorial earth for absorption, which is an inexplosive and incombustible material, and reduces the explosive power 67 per cent. of the pure trinitro-glycerine, as about eight parts of the latter are used in heating the infusorial earth when exploding. Explosive gelatine consists of 8 per cent. of guncotton and 92 per cent. of trinitro-glycerine. Its explosive power is not much less than that of the explosive oil. When the latter is represented by 1,380 the former is 1,350 (according to trials with Trauzl's explosive measurer). Explosive gelatine is much to be preferred to dynamite on account of its great safety in transport, storing, and handling; a blow of 3·5 kg.m. (25·3 foot lbs.) will not explode it, and when slowly heated explodes at 204° C. (399·2° F.), and when quickly heated, at 240° C. (464° F.), while diatomaceous dynamite explodes with a blow of 1 kg.m. (7·23 foot lbs.), and on heating to 180° C. (356° F.) The composition of gelatine dynamite is as follows:—

Gelatine Dynamite (1).

65 per cent. gelatinised nitro-glycerine ...	97·5	per cent.	nitro-glycerine.
	2·5	„	collodium wool.
35 per cent. mining powder	75·0	per cent.	saltpetre.
	24·0	„	cellulose.
	1·0	„	soda.

Gelatine Dynamite (2).

45 per cent. gelatinised nitro-glycerine ...	97·5	per cent.	nitro-glycerine.
	2·5	„	collodium wool.
55 per cent. mining powder	75·0	per cent.	saltpetre.
	24·0	„	cellulose.
	1·0	„	soda.

The author divides the chemical part of his paper into two divisions. The first deals with the existing methods of determining the nitrogen in nitrogen compounds, besides the experiments conducted at the Clausthal Laboratory, and describes a new quantitative analytical method of determining nitrogen. The second deals with the ways and means of quantitatively analysing and dividing the different nitrogen compounds. The methods of Dumas, Walter Hempel, Beckerhinn, Filip Hess, Champion, and Pellet, and nitrometric methods containing a description of various nitrometers, together with results of analyses of saltpetre, gunpowder, gelatine, dynamite, guncotton, and trinitro-glycerine, are detailed at some length in the first part. C. Z. B.

ON WINDING WITH A SHEAVE INSTEAD OF A DRUM.

Untersuchungen über die Förderung mit Treibscheibe. By HERR BAUMANN. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im Preussischen Staate. Vol. XXXI. B., pp.* 173–186.

Winding by a sheave was first introduced by Herr Köpe at the Hannover Colliery (Westphalia), and consists in attaching a pulley to the winding engine, instead of drums around which an endless rope passes. The sheave is placed directly over the shaft, and the cages either serve as connecting links between the winding rope and the counterbalance rope, or there is only one rope used, which passes through the cages, the cages being held by patent caps.

Let P represent half the weight of the rope and the weight of the empty cage (inclusive of empty tubs or trams), and Q equal half the weight of the rope and the weight of the cage with coal and tubs, then sheave winding can only be possible when

$$Q - P = \mu (Q + P).$$

In order to determine the coefficient of friction μ, the author made a number of trials upon sheaves whose treads were lined with oakwood, leather, or cast iron, of which the following table is an analysis:—

Wire Rope.			Tread of Sheave.			No. of Trials.	$\mu =$
Diameter.		Material.	Diameter.		Material.		
Mm.	Ins.		M.	Ft.			
16	0·63	Steel (old) ...	2·2	7·2	Oakwood	14	0·303
,,	,,	,, ...	4·4	14·4	,, ...	79	0·258
18	0·71	,, ...	,,	,,	,, ...	66	0·215
20	0·79	Iron (new) ...	,,	,,	,, ...	21	0·280
,,	,,	Iron (old) ...	,,	,,	,, ...	80	0·246
32	1·26	,, ...	,,	,,	,, ...	32	0·197
					A	292	0·242
16	0·63	Steel (old) ...	3·2	10·5	Leather lying flat	37	0·277
18	0·71	,, ...	,,	,,	,, ...	46	0·244
20	0·79	Iron (new) ...	,,	,,	,, ...	52	0·253
,,	,,	Iron (old) ...	,,	,,	,, ...	20	0·230
32	1·26	,, ...	,,	,,	,, ...	52	0·234
					B	207	0·248
16	0·63	Steel (old) ...	3·2	10·5	Leather lying edgeways ...	19	0·281
18	0·71	,, ...	,,	,,	,, ...	14	0·267
20	0·79	Iron (new) ...	,,	,,	,, ...	15	0·269
,,	,,	Iron (old) ...	,,	,,	,, ...	24	0·228
32	1·26	,, ...	,,	,,	,, ...	17	0·248
					C	89	0·256
15	0·59	Iron (old) ...	1·6	5·25	Cast iron	99	0·227
21	0·83	,, ...	,,	,,	,, ...	50	0·209
26	1·02	Steel (old) ...	,,	,,	,, ...	129	0·182
					D	278	0·203
					Average of all trials	866	0·232

The friction of the rope on cast iron is the least, upon wood greater, and a little greater on leather, especially when laid edgeways. The co-efficient μ decreases with an increasing diameter of the rope (probably the thinner ropes make a deeper impression on the tread) and by an increasing load (the influence of the rigidity of the rope is less by small loads).

When the trials followed quickly upon one another the resistance to friction decreased, while after greasing and pauses it increased.

In actual practice the circumstances can not be so unfavourable as purposely made in the trials, and the following figures can be taken as a basis:—

Wire rope upon cast iron	...	...	...	μ	=	0·20
„ oakwood	...	...	...	μ	=	0·24
„ leather	...	...	...	μ	=	0·25

The author deduces formulæ for the finding, (1st) the greatest useful load possible to wind under the existing circumstances; (2nd) how heavy for certain loads a rope must be, so that all danger from slipping when winding is avoided; and a number of tables are given, showing the least depth at which windings are possible with different lined sheaves and under varying weight of ropes and ratio of net to gross loads.

The tables and calculations show that when the ratio of the dead load to the useful load is 1·5 (the average ratio), a sufficient resistance to friction can be obtained for winding at all depths when the rope only covers one-half the circumference of a lined sheave, and five-fourths of a cast iron sheave. The increased surface of friction can be obtained by the use of rollers.

A brake is recommended to be used when men are raised, which should act in the sheave through the medium of the rope. Flat ropes would be preferable to round ropes with respect to greater breaking surface, and also as a counterbalance, for they have not the tendency to twist and throw themselves into loops that round ropes possess.

By adopting an endless rope which passes through the cages a winding can be carried on at different levels, by shifting the cages on the ropes, and the rope can be better economised by shifting it as it wears.

A sticking of the cage in the shaft, or an over winding, will not be so injurious to the rope with a sheave as with a drum, for in the former case the rope will slip on the sheave.

C. Z. B.

THE ORIGIN OF THE VEINS (SULPHIDES).

Zur Entstehung von Erzgängen. By Dr. Fleitmann. *Oesterreichische Zeitschrift für Berg- und Hütten-wesen*, 1883, *Part* 9, *p.* 123.

The author describes how a brick-built dung-heap had been kept water-tight by lining it with pure red clay 1 metre thick all round. This was to hinder the rain from washing through, and to prevent as much as possible spontaneous combustion, by preventing the water used in cooling it from flowing away. After two years the clay failed and the manure was removed. On taking the clay out it was found that the whole had turned white, also that the clay had become set with innumerable fissures varying from 1 to 5 millimetres in width, which were entirely filled with quite compact iron pyrites. The sesquioxide of iron in the clay, by means of the hydrosulphate of ammonia in the dung, had been turned into iron pyrites, and this had, in consequence of molecular attraction, set itself in strings of veins in the clay.

C. Z. B.

TEMPERATURE OF STRATA.

Das Wachsen der Temperatur mit Zunehmender Tiefe. Wochenschrift des Vereines Deutscher Ingenieure, 1883, *p.* 62.

The deepest shaft in the World, the Adalbert Shaft, near Przibram, has given results with regard to temperature of the rock and air respectively as follows:—

Depths.			Temperature of Rock.			Temperature of Air.		
Metres.		Feet.	Degs. C.		Degs. F.	Degs. C.		Degs. F.
190·6	=	625·34	10·8	=	51·5	11·6	=	53·4
286·3	=	939·32	12·9	=	55	13·8	=	57
395·7	=	1298·25	14·7	=	58	15·2	=	59·3
505·5	=	1658·49	16·8	=	62·3	16·6	=	61·9
581·4	=	1907·51	18·0	=	64·4	18·6	=	65·5
699·8	=	2295·97	19·1	=	66·3	19·4	=	66·9
775·2	=	2543·35	20·2	=	68·3	19·9	=	67·9
889·2	=	2917·37	22·9	=	86·0	23·3	=	73·9
1000·0	=	3280·91	24·5	=	76·1	25·0	=	77·0

C. Z. B.

EXPERIMENTS MADE WITH EXPLOSIVES USED IN MINING.

Untersuchung von Sprengmaterialien für Bergbauzwecke. By Dr. Klose. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im Preussischen Staate. Vol. XXXI. B, pp.* 91–105.

The fiscal collieries in Saarbrücken used, in the year 1881–82, 887,457 kilogrammes (873·44 tons) of gunpowder, and 15,701 kilogrammes (15·45 tons) of dynamite, having a total value of £27,259. Assuming that the rest of the coal districts use a proportional amount of explosives, then the collieries of Prussia will have consumed, in 1881, £225,000 worth of explosives.

Pistol Trial.—One of the conditions is that the powder must be made with pure nitrate of potash, must contain at least 70 per cent. of saltpetre, and not more than 1 per cent. of chlorate of potash. It must be perfectly dry, and must not soil the hands. The power must be equal to 18° or 20°. This has reference to an instrument called a pistol, which has attached to it a crucible for holding a small fixed quantity of powder, the lid of which is attached to a lever which moves a toothed wheel. On firing the powder, the wheel is turned according to the strength of the powder measured in degrees of rotation of the wheel. On account of the great difference of weight of equal quantities of powder, owing to different sizes of the grain, this mode of trial has been dispensed with in favour of other trials.

Rod Trial.—This is a similar apparatus, but instead of a wheel the cover of the crucible has a rod attached, sliding upon guides, upon which the height can be measured to which the cover with rod is thrown when the powder is exploded. This instrument was improved by replacing the crucible and lid by a cylinder and piston, for in the former case only part of the powder had effect on the lid, the rest burnt away when the cover was raised. In a table given by the author, compressed powder being taken at 15·3 (the square root of the height the powder throws the piston with rod), coarse grained powder was 13·5, mixed grained powder 13·5, and fine grained 13·1.

Lead Cylinder Trials.—In this case the enlargement of a space in the lead cylinder, by the explosion in it of powder, is the measure of the strength of the powder. A section of the cylinder after explosion shows the force of the explosive. Com-

pressed powder (not really compressed, for its specific gravity was rather less than that of ordinary powder) gave good results in the lead cylinder trials. The lead trials proved that blasting with a space is not so efficacious as when the powder fills tightly the space allowed it. This is rather important, as the effect of an air cushion has played for some time past an important part in the practice of blasting.

The Specific and Cubic Weights of Powder.—For the determining of these quantities an apparatus, devised by Major Bode, described in the text, was used. Five trials of one gunpowder gave a specific gravity of 1·6090, 1·6090, 1·6090, 1·6103, 1·6106; four trials of another gave 1·6870, 1·68602, 1·68628, 1·6870. The granulating and polishing of powder has an effect upon its specific gravity, for the surface is made denser. Coarse grained powder had a specific gravity of 1·5990, mixed grained 1·6093, and fine grained 1·6312, the powder being of the same composition in each case. The cubical weight depends upon the specific weight and the size of the grain, and is of interest to the miner, for he generally measures, and not weighs, his requisite quantity. The following table gives values for different powders:—

No.	Powder Used.	Specific Weight.	Cubic weight. 100 c. cm. (6·1 cub. ins.) weigh g=15·4 grains.	50 g (771·6 grains) enlarged the powder space by c. cm. = ·06 cub. in.	Taking No. 1 powder at 100 the relation of the others to it are—		
					Specific Weight.	Cubic Weight.	Enlargement of Powder Space.
1	St. Ingbert	1·6198	109	145	100	100	100
2	V.R.W.P.F.K.B., No. 1	1·4899	97·3	224	93	89	153
3	V.R.W.P.F., No. 17 ...	1·6871	107·3	163	104	98	112
4	Königswiesen	1·5181	100·2	187	94	92	129
5	Bous, coarse grained ...	1·5990	104·4	138	98	96	95
6	„ mixed „ ...	1·6093	111·6	147	99	102	101
7	„ fine „ ...	1·6312	106·2	175	101	97	120
8	Compressed powder ...	1·5225	144·8	250	94	133	172

Dynamite.—The power of the explosive can be easily determined by Von Trauzl's plan. The following table represents the explosive power of dynamite:—

Dynamite Tried.	Composition.	Capacity of Lead Cylinder.					
		Before Explosion.	After Explosion.				
			Trial 1.	Trial 2.	Trial 3.	Mean.	
		C.Cm. C.I.	C.Cm.	C.Cm.	C.Cm.	C.Cm.	C.I.
Dynamite No. 1, old	75 Nitro-glycerine, 25 Diatomac'us earth	50=3·05	980	920	960	953	=58
Dynamite No. 2, new	60 Explosive gelatine, 40 Mining powder	50 ...	1,200	1,200	1,250	1,217	74¼
Dynamite No. 2...	75 Explosive gelatine, 25 Mining powder	50 ...	930	950	970	950	58
Dynamite No. 3, detonator ...	25 Nitro-glycerine, 75 Mining powder	50 ...	700	740	720	720	44
Dynamite No. 3, cartridge ...	15 Nitro-glycerine, 85 Mining powder	50 ...	590	550	590	577	35
Explosive gelatine	... ...	50 ...	1,500	1,550	1,500	1,517	92½
Nitro-glycerine...	... ...	50 ...	1,790	1,750	1,790	1,777	108½

Comparisons of power of dynamite and gunpowder cannot be relied upon when made with lead cylinder trials, for by them the pressure is sixteen times stronger than

the latter, a result which does not agree with experience. The shape of the lead cylinder after explosion with dynamite differs from the shape after explosion with powder; the former enlarges the space at the bottom, the latter in the middle. Figures of the spaces are in the text. Trials made with stemmings of water and sand show them to be of equal value.

Burnt Lime.—Comparisons were made with powder and lime with the lead cylinders. The lime was procured from two districts, powdered and immediately pressed by a pressure of 35½ tons.

On account of the cartridges swelling directly they were taken from the press they were immediately put into the lead cylinder without having time for weighing.

	The Blasting Chamber		
	Before the operation.	After the operation.	Enlargement.
	C.Cm.	C.Cm.	C.Cm.
Champagne chalk ...	130·8 ...	138·0 ...	7·2
Saar chalk	133·2 ...	145·5 ...	12·3

In mild soft coal this form of blasting may be possible, but certainly not with the Saarbrücken coal. Increased diameter of boreholes, difficulty of manufacture of cartridges and transport of the same, and the difficulty of pumping effectually the water into lime are obstacles which are not conducive to its general or even partial introduction. C. Z. B.

THE SOEKABOEMI COAL-FIELD.

Onderzoekingen im het kolenterrein bij Soekaboemi, etc. By J. A. HOOZE. *Jaarboek van het Mijnwesen in Nederlandsch Oost-Indië,* 11*de Jaargang,* 1882, *Part I., pp.* 1–79, *with folding Map and one Plate.*

The coal-field reported upon in this memoir is about 110 square kilometres in area, and lies in the northern portion of the Tjimahi district of the Soekaboemi province, in the Government of Preang, due south of Mount Panderango. It is now provided with a railway, and is likely to become commercially important. The coal occurs in rocks of Eocene age, which are, in that part of Java, bent into a few great synclinal and anticlinal folds, thus bringing the seams several times to the surface. These rocks are chiefly quartzose sandstones. Much more detailed information is given in this paper respecting the nature of the coal-seams than in the earlier one by HUGUENIN (see Trans. N. Engl. Min. Inst, Vol. XXXII., Abstr., p. 2), a table of comparative analyses, showing the probable relative value of the coals, being of special importance. The following gives the average composition of the Soekaboemi coals:—

Carbon	71·20
Hydrogen	5·62
Oxygen and nitrogen	12·91
Sulphur	0·63
Water	2·00
Ash	7·64
	100·00

This result coincides very closely with a similarly drawn up analysis of the Orange-Nassau coals of Borneo. G. A. L.

MINERAL RESOURCES OF N.E. SICILY.

Brevi cenni sulla geologia della parte N.E. della Sicilia. By E. CORTESE. *Bollettino del R. Comitato geologico d'Italia, Vol. XIII.*, 1882, *pp.* 105–137, 161–189, 308–357, *with folding Plate of Sections (Plate VIII.)*

The geological divisions recognised in this region by the author are (in ascending order):—

1.—*Archæan* or *Pre-Cambrian* gneisses, micaschists, and granites.

2.—*Silurian* (?) lustrous and micaceous schists with subordinate crystalline or dolomitic limestones. Some granites are also referred to this age.

3.—*Permian* (?) quartzites, schists, grits, conglomerates, and brown limestones.

4.—*Trias* in three fully-developed groups, chiefly calcareous, with conglomerates and grits at the base of the Middle or *Muschelkalk* division.

5.—*Infralias* limestones.

6.—*Lias*, Lower, Middle, and Upper, chiefly calcareous.

7.—*Oolites*, Lower (*Dogger*) limestones, and Upper (*Tithonian*), also calcareous. The Middle Oolites are absent.

8.—*Cretaceous*, Middle (*Cenomanian*) calcareous marls alone present.

9.—*Eocene*, Lower with nummulitic limestones, conglomerates of old rocks, clays, and sands; Middle clays and marls; Upper or *Albarese* limestone.

10.—*Miocene*, Lower (*Tongrian?*) clays and sands; Middle (*Elvezian?*) calcareous sandstones and coralline limestones; Upper (*Sarmation* and *Tortonian*) conglomerates, sands, clays *Molasse*, estuarine and locustrine beds, Tripoli.

11.—*Pliocene*, Lower (*Zanclean?*) clays, siliceous and other limestones, foraminiferous marls, sulphur beds, and calcareous sands; Upper (*Astian*) sands, coralline limestones, etc.

12.—*Quaternary* alluvia.

13.—*Recent* alluvia.

The useful rocks and minerals in the above series, and occurring in the Province of Messina, are distributed as follows:—

Marbles and Building stones, whether calcareous or siliceous, occur in all the divisions, and ornamental *granites* in 1 and 2.

Clays fit for pottery and other purposes in Nos. 1, 2, 9, 10, 11, and 13.

Grindstones in 2, 3, 4, 9, 10, and 13.

Sulphur at the base of 11 or more exactly between 10 and 11.

Lignite in 10.

Bituminous shales in 9.

Galena, antimony ores, copper ores, siderite, graphite, and *garnets*, in 2.

Lastly, *mineral waters* of various kinds are known in 1, 2, 3, 12, and 13.

G. A. L.

GEOLOGY OF THE NEWCASTLE COAL-FIELD.

Note sur la géologie du bassin houiller de Newcastle. By A. SOUBEIRAN. *Annales des Mines, 8th Series, Vol. I.*, 1882, *pp.* 409–448, *Plates VI. and (in part) VII.*

A compact and acknowledged compilation of the chief facts relating to the geological structure of the Great Northern Coal-field, from the works of Hull, Lebour, Ramsay, Simpson, and others, and from personal observation. Professor Hull's map of the coal-field is reproduced in Plate VI., and Mr. J. B. Simpson's sections are given on a reduced scale in Plate VII. The details as to the Coal-seams of the Coal-Measures and Bernician

series are those published by Professor Lebour in 1878. With regard to the amount of workable coal beneath the sea the author believes the estimate made by Mr. Greenwell to be too great, and makes the following observations:—"When the coal had been won, and the roof had fallen over so great an area, fractures would be produced through which the sea would penetrate with inconceivable violence." He then cites the Workington accident as a case in point. He would, therefore, restrict the possible area of possible coal-getting beneath the sea to 4 or 5 kilometres from the shore, and gives the following as the workable area of the entire coal-field, in square kilometres:—

Area of the exposed Coal-Measures	1,150
Area of Coal-Measures concealed by Permian rocks	560
Workable area of Coal-Measures beneath the sea	270

G. A. L.

STRONTIANITE MINES OF DRENSTEINFURT.

Beschreibung des Strontianit-Vorkommens in der Gegend von Drensteinfurt, sowie des daselbst betriebenen Bergbaues. By PAUL MENZEL. *Jahrbuch der Königlich Preussischen geologischen Landesanstalt und Bergakademie zu Berlin für* 1881. *Part* 2, *pp.* 125–143, *two Figures in text.*

This paper is in three parts. The first gives a sketch of the geology of the country round Drensteinfurt, the second describes the strontianite veins, and the last refers to the mode of working the deposits and their commercial value.

The district is composed of Cretaceous rocks, and the veins of strontianite occur in the so-called *Mukronatenkreide*, or, in other words, in the Chalk zone characterized by *Belemnites mucronatus*. These beds lie flat, and the veins, which do not appear to be also faults, hade from 10° to 20°, and run, some in a N.N.E. and S.S.W. direction, others E.E.N. and W.W.S. The chief groups of veins are those (1) of Drensteinfurt, (2) those between Rinkerodde and Ascheberg, (3) of Albersloe, and (4) of Ahlen. Some of the veins are known along a length of 4,500 metres, and their average breadth is about 30 centimetres, with a maximum of 2·5 metres. Strontianite is the chief material of the veins, but calcite, marl, and iron pyrites are found associated with it, the calcspar forming the ordinary selvages.

Two analyses of the strontianite, by H. REDICHER, give the following results:—

	(1.)	(2.)
$SrCO_3$	94·70 ...	93·09
$CaCO_3$	5·22 ...	6·82
Fe_2O_3	Trace ...	Trace
H_2O	0·08 ...	0·08
Total	100·00 ...	99·99

The age of the veins is shown to be Tertiary, or, at least, Pre-Quaternary. They have been worked since 1839, but on a comparatively large scale only since 1874. There are now a number of small shafts whence levels are driven to the veins in the ordinary way. The Bernhardt shaft, which is figured as an example, is 24 metres deep.

The strontianite is sold almost exclusively for use in sugar refinery at a maximum price of from 8 to 10 marks (= shillings) per centner. G. A. L.

GOLD IN FRENCH GUYANA.

Note sur le gisement et l'exploitation de l'or à la Guyane française. By — FLORY. *Annales des Mines, 8th Series, Vol. I., pp.* 1882, 463–486.

Gold was first discovered in Guyana by a Brazilian Indian, named Paoli, in 1853, on the banks of the Appruagua River. Since then it has been found in drift and alluvial deposits in a number of other river-valleys. The production in kilogrammes in the different river-basins is thus given :—

	1877.	1878.	1879.	1880.
Maroni	103,968	111,077	62,311	10,307
Oyapock	16,565	21,945	17,801	14,840
Approuague (Appruagua)	313,362	261,729	225,553	149,281
Roura (Rura)	161,848	143,449	190,010	145,498
Kourou (Kuru)	0,476	0,763	5,273	4,630
Sinnamary	750,869	742,289	714,058	786,226
Mana	258,899	435,483	965,468	758,807

The auriferous beds consist in all cases of gravels, bits of quartz often "resinous," and fragments of divers rocks and minerals cemented in a reddish clayey matrix. They generally lie upon a thin blue clay, which itself rests upon a universally distributed conglomerate locally known as *roche à ravets*. Although the quartz is often quite angular, it has, apparently, not yet been in any case traced to the parent reefs which doubtless occur in the mountains. The seasons greatly influence the gold diggings. These are at their best at the close of the rainy season, at their worst at the close of the dry season and during the rains. G. A. L.

METALLIFEROUS PRODUCTS OF MURCIA (SPAIN).

Note sur la situation de l'industrie minière dans la province de Murcie. Extracts from a French Consular Report, Annales des Mines, 8th Series, Vol. I., 1882, *pp.* 588–590.

For mining purposes the Province of Murcia is divided into two districts, that of Carthagena and that of Mazarron. In the former, ores of lead, zinc, and iron, are worked. Lead ore occurs in veins, flats, lenticular masses, and as irregular deposits, and in 1878 was worked to the extent of 150,000 tons. In the following years rather less has been got—from 120,000 to 130,000 tons per annum. Deposits of blende and calamine were largely worked ten or twelve years ago, but have gradually been abandoned. Manganesiferous iron ores are widely distributed, and occur in abundant masses near the surface. It is therfore easily and cheaply won, and the production is large, averaging from 500,000 to 600,000 tons per annum from 1879 to 1881. This ore contains as a mean 15 to 18 per cent. of manganese, and 30 to 36 per cent. of iron. Non-manganesiferous iron ore is also found, but in much smaller quantities, the average yield being about 150,000 tons per annum.

Argentiferous galena is the chief mineral product of the Mazarron district, where it occurs chiefly in very regular veins. This lead-field is stated to be in its infancy, and promises to become, in the near future, richer than that of Carthagena. In 1881 the production was more than 30,000 tons. G. A. L.

THE COAL-BEARING BEDS OF THE NORTHERN HARZ.

Die Steinkohlen-führenden Schichten bei Ballenstedt am nördlichen Harzrande. By CH. E. WEISS. *Jahrbuch der Königlich Preussischen geologischen Landesanstalt und Bergakademie zu Berlin für* 1881, *Part* 1, *pp.* 595-603. *Two figures in text.*

The oldest rocks, forming a marginal zone round the Harz, are the Lower Permian (Rothliegende), and certain coal-bearing beds which occur on the south as well as on the northern flank of the *massif*. The latter, which are best developed about Ilefeld, were formerly regarded as of Coal-Measure age, but more recently they have been referred to the lowest portion of the Rothliegende by the officers of the Prussian Geological Survey. The question of the relation between these beds and those at Meisdorf and Opperode, near Ballenstedt, on the north side of the mountains, and also with those at Grillenberg on the south side, then arises. These points are fully discussed in the present paper, the author relying chiefly on evidence derived from the fossil plants occurring in the strata in question. The conclusion arrived at is that in the Ballenstedt district these beds belong to the Rothliegende and not to the Upper Coal-Measures.

The workable seams mentioned are only one of true coal 5 to 8 decimetres thick, and one of slaty coal 8 to 10 decimetres thick. These deposits are associated with shales and sandstones of the ordinary Coal-Measure type, with some impure cherty limestone.

Figures of two new species of plants are given, viz.:—*Callipteris catadroma*, and *Sphenopteris Losseni*. All the species found in the neighbourhood of Ballenstedt are thus tabulated:—

Sigillaria Brardi ...	known in the Upper Coal-Measures and in the Rothliegende.				
Sigillarian leaves ...	"	"	"	"	(?)
Sigillariostrobus ...	"	"	"	"	(?)
Asterophyllites equisetiformis	"	"	"	"	"
Macrostachia sp. ...	"	"	"	——	——
Pecopteris arborescens...	"	"	"	"	"
P. abbreviata	"	"	"	"	"
P. oreopteridia	"	"	"	"	"
Sphenopteris germanica	——	——	——	"	"
Sph. erosa	——	——	——	"	"
Sph. Losseni	——	——	——	——	——
Callipteris catadroma ..	——	——	——	"	"

From this list it appears that out of twelve forms five are known to be common to the Coal-Measures and Rothliegende, two *may* be common to both, one had hitherto been found in the Coal-Measures only, there are two Rothliegende species only, and one has, so far, only been found in the Ballenstedt beds.

G. A. L.

KAADEN-KOMOTAU TERTIARY BEDS (BOHEMIA).

Die tertiären Ablagerungen in der Umgebung von Kaaden-Komotau und Saaz. H. BECKER. *Jahrbuch der Kaiserlich-Königlichen geologischen Reichsanstalt, Vol. XXXII.*, 1882, *pp.* 499-536. *Two Plates.*

Describes the occurrence of the seven members into which the author divides the deposits, and gives measurements of the thickness of the beds composing Nos. 3 and 5 (from the surface), which contain numerous coal-seams up to 8·35 metres thick.

G. E. L.

GOLD REEF WORKING IN WEST BORNEO.

(1) *Onderzoek van goudaders bij Sjoei-Tsiët. By* C. J. VAN SCHELLE. *Jaarboek van het Mijnwesen in Nederlandsch Oost-Indië,* 12*de Jaargang,* 1883, *Part* 1, *Technical division, pp.* 5–22. *with three Plates.*

This paper forms No. 4 of the series of Reports of the Government Geological and Mining Survey of the West Coast of Borneo. Full descriptions of a number of quartz veins, some auriferous and some not, which are known and worked in the neighbourhood of Sjoei-Tsiët, not far from the Chinese settlement of Selingse. The reefs are in granite, and run in a general east and west direction across the valley of the Bani River. It seems probable that the placer workings in the drift deposits filling portion of this valley (as at the Sim-pi-toë mine already described in Institute Transactions, Vol. XXXII., Abstr., p. 2), are due to the presence of these and similar reefs in the granite hills around. The quartz of the veins is in parts impregnated with iron pyrites and gold, with occasional lumps and lenticular masses of purer quartz and ore. At the end of 1881 about 225 coolies and other men were employed working some of the reefs. The stamped vein-stuff yields from 6 to 35 milligrammes of gold per kilogramme.

(2) *Onderzoek naar het voorkomen van goud op den berg Hang-oei-san. By the same Author. Ibid., pp.* 23–36, *with folding Plate.*

A similar paper to the last, No. 5 of the same series. In this case the gold is found in a quartz vein cutting through the stratified rocks (sandstone, conglomerate, and clay beds) of the Hang-oei-san Mountain, about three and a half kilometres east of Montrado. The deposits are worked by Chinamen. G. A. L.

BELGIAN PHOSPHATIC DEPOSITS.

La Craie phosphatée de Ciply et son traitement. By E. SOLVAY. *Société des Ingénieurs sortis de l'école provinciale d'industrie et des mines du Hainaut, Ser.* 2, *Vol. XIII., pp.* 119–126.

The grey phosphatic chalk of Ciply has been known for many years, but it is only recently that various attempts have been made to utilise the enormous amount of phosphoric acid which it contains. Now the deposit is worked actively, the object of the processes employed being to free the natural material from a portion of its carbonate of lime, and thus obtain a product capable of being converted into superphosphates. The Ciply chalk varies in composition, the percentage of phosphate ranging from 4 to 60 and even more. Moreover, samples containing similar percentages of phosphate are not identical. Generally it may be said that the proportion of silica is larger the poorer in phosphate is the chalk. The stone is a mixture of fine light white chalk powder and brown heavier and larger grains, which are easily separated from the rest by washing. These have a much more uniform composition than the mixture, yielding from 30 to 40 per cent. of phosphate. The author describes a new process of extraction which consists essentially in calcining the washed material, and then quenching it in boiling water under pressure. G. A. L.

GEOLOGY OF THE GOLD COAST.

Beiträge zur Geologie der Goldküste in Afrika. By C. W. GÜMBEL. *Sitzungsberichte der mathematisch-physikalischen Classe der k. b. Akademie der Wissenschaften zu München, Vol. XII.*, 1882, *pp.* 170–196.

A short general account of the previous knowledge of the gold-bearing reefs and alluvia of the Gold Coast, according to Soetbeer, Bonnat, Dahse, Lenz, Skertchly, and others, is succeeded by more detailed notes on the following districts:—1.—The Tacquah hills in the Wassaw country, where gold occurs associated with Itabirite, very like the well-known *Jacotinga* rock of Brazil, and not in true veins. 2.—The Ankobrah country. 3.—Axim, at the mouth of the Ankobrah river. 4.—Accra, in the east. 5.—Devil's Hill.

In all these regions the rocks are crystalline, and more or less auriferous where they are quartzose. The gold dust obtained is, according to Wiebel, very pure, that in grains (*körnergold*) often contains as much as 50 per cent. of other metals as impurities—chiefly silver, copper, zinc, tin, and lead ores. G. A. L.

THE ORIGIN OF COAL.

Mémoire sur la formation de la houille. By C. GRAND 'EURY. *Annales des Mines, 8th Series, Vol. I.*, 1882, *pp.* 99–292, *Plates I.–IV.*

An elaborate discussion of the whole subject in twelve sections grouped under two heads as follows:—

Part I.—Botanical and stratigraphical. Section 1.—Disintegration and decomposition of fossil plants. 2.—Mode of occurrence of plant remains in rocks. 3.—Structure of coal and arrangement of its constituent plants. 4.—Stems and roots *in situ*. Carboniferous forests. 5.—Stipites and lignites. 6.—Peats and other accumulations of vegetable matter. 7.—Critical review of theories as to the formation of coal.

Part II.—Physical and chemical. Section 1.—Fossil states of plant remains in rocks. 2.—Physical properties of coal. 3.—Comparative characters of stipites, lignites, and peats 4.—Circumstances which have attended conversion into coal.

The general conclusions arrived at may be thus summarised:—Coal is undoubtedly of vegetable origin, but, with the exception of *Stigmaria*, none of the plants of which it is formed are in place. Coal is, in fact, as much a sedimentary rock as shale, and the vegetation to which it is due is drifted material. At the present day coal is being formed in the peat turbaries, lacustrine conditions prevailed in the lignite period, whereas in Coal Measure times coal was formed uniformly by transportation in slowly sinking basins. The transformation of drifted vegetable matter into coal began by amylaceous products, and the cellular tissues and bark were the first to be attacked. Slowly formed of gradually accumulating humus, bark, and leaves, coal-seams are not less than half their original thickness. At first a kind of homogeneous paste, remaining soft longer than the encasing rocks, the conversion into hard and lustrous coal was completed by slow dessication carried on at moderate temperatures. Coal is, in fact, the result of the dehydration and deoxidizing by the wet way of buried vegetable substances.

The author admits that his views are in most respects a retrograde repetition of those held by many geologists fifty years ago. G. A. L.

COALS AND BITUMEN OF TRINIDAD.

Étude sur les gisements de charbon et de bitume de la Trinidad. By — CUMENGE. *Annales des Mines, 8th Series, Vol. II.*, 1882, *pp.* 137–184. *One Plate.*

The coals described are:—1.—Those of Manzanilla which the author regards as not profitably workable. They are of Tertiary age, and lignitic in character. 2.—The Williamsville coal, 4 feet thick and nearly vertical. This is also of Tertiary age and its powdery nature and dip render it of little or no commercial value. 3.—The Piparo coal, which the author was specially sent to report on, occurs in the Paria formation regarded as Neocomian by Wall and Sawkins, the Government geologists, and as being more probably Tertiary by M. Cumenge. There are three seams here, 0·20 metre, 0·25 metre, and 0·50 metre thick respectively, which consist of true coal of excellent quality. The mean analysis given shows:—fixed carbon, 52·6; volatile matter, 45·0; ash, 3·6; with a calorific power of 77·8. These seams may be profitably worked in the future.

The deposits of bitumen described are:—1.—The well-known Asphaltum of the La Brea Lake. 2.—The so-called Glance-Pitch recently discovered in the Guaracaro quarter of the Montserrat district, forming a bed 1·20 metres thick encased in marly clays. The exact age of these beds is not known, but they are not older than Pliocene.

G. A. L.

BULGARIAN COALS.

Untersuchungen verschiedener Kohlen aus Bulgarien. By C. VON JOHN. *Verhandlungen der k. k. geologischen Reichsanstalt, Vol. XVII.*, 1883, *pp.* 99, 100.

Gives the coefficient of heat-power (Berthier's method) and percentages of water and ash of the following coals from Bulgaria:—Triassic coal from Bělogradčik; Liassic coal from Trewna: Neocomian coal from Kunino, near Wratza; Tertiary (Miocene probably) brown coals from the Sofia basin; from Dospey, near Samakov; Gorno Ujno, near Küstendji; and Pernik, near Radomir. G. A. L.

THE AUBIN COAL-FIELD IN AVEYRON.

Mines de houille et fabrication de la fonte dans le bassin d'Aubin. By — COLRAT. *Bulletin de la Société de l'Industrie minérale, Ser. 2, Vol. XI., pp.* 1,043–1,080. *One folio Plate.*

The coal-field occupies a triangular area, 8 kilometres broad at the base and 10 kilometres long. It is worked by five companies. The Coal-Measures rest on ancient crystalline rocks, and their prevailing beds are sandstones which attain in places a thickness of more than 40 metres. The greatest total thickness of the coal-seams is 70 to 80 metres (in the Decazeville and Combes district) in the centre of the field. The seams are much subject to thickening and thinning. One (that of Bourran) is as much as 70 metres thick near its central point, but soon falls to 40 metres to the east and to 2 or 3 metres to the west. The succession of the seams is also very irregular. Clay ironstone is abundant in the coal-field, accompanying the coal and often taking its place. Two principal zones of this ore are known. The whole of the beds of the basin are referred to the Upper Coal-Measures of Central France. The coal appears to be, in character, midway between household and gas coal, but it varies in quality in different parts of the region. A geological map by A. JAUSIONS, and some sections showing the lie of the beds, illustrate the paper. G. A. L.

COALS AND METALLIFEROUS DEPOSITS OF INDO-CHINA.

Mémoire sur l'exploration des gites de combustibles et de quelques-uns des gites métallifères de l'Indo-Chine. By EDMOND FUCHS *and* E. SALADIN. *Annales des Mines, 8th Series, Vol. II.*, 1882, *pp.* 185-352, *Plates VI.–XII.*

The ground covered by this paper includes a large portion of the Siamese Empire, Cambodia, French Cochin-China, Annam, and Tong-king. The mineral resources of the two last-named regions are most fully treated of. In ascending order the sedimentary rocks of these countries are:—1.—Ancient schists, with staurolite, etc. 2.—Devonian schists and grits. 3.—Carboniferous Limestone. 4.—So-called Coal-Measures, lying unconformably upon the limestone, and overlain by (5) a series of variegated grits and clays. 6.—Alluvium. Besides these, there are granitic, porphyritic, and volcanic rocks of various kinds. The "Coal-Measures" mentioned above are allied to the Gondwana series of India, and are therefore not of true Carboniferous age, but Triassic to Liassic. The plants characteristic of these beds are described by M. ZEILLER, and figured in some of the plates in the present paper.

The principal coal-fields in these rocks are, so far as yet known, those of Tong-king, Yun-nan, the Tinh-Hoa province, Nong-Sön (Annam), and Laos, more especially the Bassac basin on the Mé-Kong.

Chapter II. (pp. 230-277) consists of details respecting the position, thickness, and probable commercial value of the seams found in these coal-fields, many of which are stated to be of good quality, and some of which attain a thickness of three metres. Chapter III. is a description of the iron deposits of Ph'nom-Dêck, to the N.E. of the Cambodian Lake of Tonlé-Sap. These deposits consists of a vertical mass of magnetite, red hæmatite, limonite, and spathose iron ore encased in porphyritic and granulitic rocks. The visible volume of this mass of ore is calculated to be two and a half million cubic metres.

G. A. L.

MINERAL RESOURCES OF BRAZIL (PROVINCE OF MINAS-GERAËS).

L'Industrie minérale dans la province de Minas-Geraës. By A. DE BOVET. *Annales des Mines, 8th Series, Vol. III.*, 1883, *pp.* 85–122.

The minerals worked in this province are gold, platinum, iron, lead, and manganese ores. Diamonds and many coloured gems, such as topaz, beryl, garnet, amethyst, etc., and graphite. The present paper, which is the first part of a comprehensive memoir, deals chiefly with the iron ores, which are both rich and abundant—so abundant indeed that some of the towns (Ouro-Preto for example) are largely built of them. These iron ores are principally itabirite, and the well-known auriferous jacutinga, micaceous iron ore, specular iron ore, a hard and tough hæmatite, and lastly a ferruginous conglomerate known locally as *canga*, which covers immense areas situate at the foot of the hæmatite deposits, and which is evidently due to their waste and decomposition. Magnetite is occasionally found associated with all these ores. The latter are remarkably pure, the only gangue accompanying them being quartz, and then rarely more than 3 to 6 per cent. Manganese occurs in all—sometimes as much as 9 per cent. All the deposits occur in huge masses, and crop out at the surface. Those at the foot of the Serra de Caraça alone contain, according to M. GORCEIX, 8,000,000,000 tons, and the others are on the same scale. No true coal is, unfortunately, known in the region, but in the centre of the iron-field, at Fonseca and Gandarella, respectively east and west of the Serra de Caraça, there are two basins of lignites of late Tertiary or sub-recent age. The seams of the western basin are workable, and might be used in smelting the ores. The forests, however, are still very large, and must be regarded as the real source of fuel in any estimate of the iron-making capacities of this extensive region.

G. A. L.

MINES OF VIALAS.

Notice sur les mines et usines de Vialas. By H. GARNIER. *Bulletin de la Société de l'Industrie minérale. Sér.* 2, *Vol. II.*, 1882, *pp.* 995–1,034.

After describing the situation of the mine among the granites of Mount Lozère, the author proceeds to classify the veins (worked for argentiferous galena) according to their age. He notices the phenomenon of their reopening, and the influx of an ore long subsequent to their formation, also mentioning the deposition of ore in openings that had remained some time empty. Determining their relative ages from the crossings and the inclusion of one vein-stuff in another, he takes them in order according to their classification, and describes their occurrence, contents, and amount of galena. A vein, elsewhere poor, is described as containing nodules of galena near its intersection with a richer vein. The amount of silver varies from 280 to 700 grammes in 100 kilogrammes of lead, and figures are given to prove that the proportion of silver to lead increases with the increase of that of galena to vein-stuff. The paper next describes the mechanical separation of the different products, giving a tabular statement of the various operations, after which comes a description of the metallurgical treatment, with analyses of the products at the different stages of the work.

G. E. L.

SOAPSTONES, CHINA CLAYS, AND FIRE CLAYS OF THE SOUTHERN UNITED STATES.

The Southern Soapstones, Kaolin, and Fire Clays, and their uses. By PROFESSOR P. H. MELL, JR. *Transactions American Institute of Mining Engineers, Vol. X.*, 1882, *pp.* 318–322.

Soapstone occurs throughout the metamorphic rocks of Alabama, Georgia, South Carolina, and North Carolina. Seven analyses of this stone are given, and it is stated to be extremely refractory and useful for furnace lining. In using soapstone for such purposes the blocks must be placed with the cross-section of the grain exposed to the fire, otherwise it will crumble and flake.

Kaolin is found in similar rocks in many portions of Alabama and Georgia. Two analyses are given, which show good porcelain-making proportions.

Fire clay suitable for brick making is found in vast quantities, and associated with buhrstone, near Claiborne, on the Alabama River. G. A. L.

GOLD AND SILVER IN ARIZONA.

The Geology and Veins of Tombstone, Arizona. By WILLIAM P. BLAKE. *Transactions American Institute of Mining Engineers, Vol. X.*, 1882, *pp.* 334–345. *Seven Figures in text.*

The geology of this region consists of granite upon which rests a series several thousand feet thick of perfectly conformable quartzites, limestones, and shales dipping from 20 deg. to 45 deg. to the east. This series is probably of Carboniferous age. Intrusive porphyritic dykes cut through the beds approximately in a north and south direction. This is also the direction of the principal faults and veins. The ores of the district occur in veins and "flats" (so-called bedded ores) apparently associated with the intrusions of igneous rocks. "The output of gold and silver up to the 1st January, 1882, aggregates 7,359,200 dollars, and over 3,000,000 dollars have been disbursed in dividends." A table of the production of the various mines is given. G. A. L.

GOLD IN SAN DOMINGO.

The Gold Fields of the southern portion of the Island of San Domingo. *By* RICHARD P. ROTHWELL. *Transactions American Institute of Mining Engineers, Vol. X.*, 1882, *pp.* 345-354.

The central mountain chain of San Domingo consists of syenitic rocks. These are flanked and covered, *first* by a folded and broken metamorphic series of slates, conglomerates, and limestones of Cretaceous age, and *secondly* by Miocene and Pliocene beds. Quartz veins, sometimes auriferous, are frequent in the Metamorphic Cretaceous series. These veins, however, invariably coincide with the bedding-planes, and are not therefore true fissure veins. They are most numerous near the central core of eruptive rock; there they are gold-bearing, and there only. The river sands are barren in the syenite region, but become auriferous on reaching the slates. Although all the gravels below the slate zone encircling the syenite mountains contain more or less gold, yet the quantity available is, according to the author, far too small to make their working commercially profitable. The veins are likewise unlikely to prove remunerative.

G. A. L.

KANAWHA COAL (WEST VIRGINIA).

Notes on the Hard-Splint Coal of the Kanawha Valley. *By* STUART M. BUCK. *Transactions American Institute of Mining Engineers, Vol. X.*, 1882, *pp.* 81–85.

The Kanawha splint coal is hard, dull in lustre, coarsely fibrous in structure, very pure, and resists atmospheric influence. It kindles readily, burns with a bright flame, but does not cake. The Coalburg Seam is the chief one of this kind. It is 3 feet 8 inches to 4 feet 6 inches thick, including a worthless band of 6 to 8 inches, known locally as "niggerhead." The coal seems to occupy a large extent of country, and thickens towards Paint Creek. It has been worked for more than seventeen years on the line of the Chesapeake and Ohio Railway, chiefly at Coalburg. G. A. L.

TENNESSEE HÆMATITES.

Some Drift Hæmatite Deposits in East Tennessee. *By* EDWARD NICHOLS. *Transactions American Institute of Mining Engineers, Vol. X.*, 1882, *pp.* 480–482.

Describes deposits of gravel ore which occur at the base of a series of low foothills or knobs, composed of Clinton shales carrying seams of fossiliferous hæmatites. Analyses of the drift ore and of that of the seams which are given show the former to be much the richer in iron and poorer in phosphorus. The author thinks it is difficult to connect the two ores. The percentages of metallic iron in the gravel ores are 59·05 and 62·72, of phosphorus 0·075 and 0·054. Unfortunately these deposits are quite limited in extent. G. A. L.

ZINC IN VIRGINIA.

Note on the Falling Cliff Zinc Mine. *By* F. P. DEWEY. *Transactions American Institute of Mining Engineers, Vol. X.*, 1882, *pp.* 111, 112.

The ore in this mine occurs filling a vein with a very irregular hade, situated in No. 2 Limestone of the Trenton formation. It is a silico-carbonate, with from 59·88 to 61·99 per cent. of zinc oxide, according to three full analyses given. The amount of ore cannot yet be ascertained exactly, but is proved to be very large. G. A. L.

GOLD OF NORTH CAROLINA.

Some peculiarities in the occurrence of Gold in North Carolina. By PROFESSOR W. C. KERR. *Transactions American Institute of Mining Engineers, Vol. X., pp.* 475, 476. *One Figure in text.*

Note of occurrence of gold:—1.—In decomposed gneiss at the Rhodes Mine, Gaston County. 2.—In a felspathic schist at a mine in Moore County. 3.—In seams of quartz in a blue hydro-micaceous schist, and in a greyish blue, fine-grained, schistose limestone at King's Mountain Mine, in Gaston County. 4.—In a singular concretionary, conglomerate schist, containing *Palæotrochis*, in Montgomery County. 5.—In thin-bedded quartz slates, often pyrophyllitic and felspathic, in Montgomery, Davidson, and Randolph Counties. 6.—In the grey much-jointed quartzites and felsites of the Huronian Hills on the eastern side of the great slate belt. 7.—In a trap dyke, near Charlotte. G. A. L.

THE FUTURE OF NORTH AMERICAN OIL.

The amount of Oil remaining in Pennsylvania and New York. By HENRY E. WRIGLEY. *Transactions American Institute of Mining Engineers, Vol. X.,* 1882, *pp.* 354-360, *with Sketch map.*

The area of the oil-region in Pennsylvania and New York is stated to be about 4,250 square miles, as proved by borings. The boundaries of this area are very clearly defined. The southern limit is fixed by the depth to which the dip carries the oil-gathering sponge-rock being such that the temperature of the earth there precludes the existence of hydro-carbons in any other but the gaseous state; the eastern limit is the line where all the fissures of the anticlinal and synclinal folds have come to the surface; the western limit is where the folds of the beds have all died out and there are no fissures to allow the gas to rise; and the northern limit is chiefly due to the same cause. "On the east there is no cover, on the west and north it is all cover and no crevices within reach of a proper depth of temperature, and on the south the reservoirs are all below the line of temperature" (p. 357). The details of the oil production of the area are fully discussed, and lead the author to the conclusion that there is a total of 96,000,000 barrels of oil only left in the country, the present yearly output being 25,000,000. G. A. L.

MINES OF SOUTHERN NEW MEXICO.

The Mineral Regions of Southern New Mexico. By DR. B. SILLIMAN. *Transactions American Institute of Mining Engineers, Vol. X.,* 1882, *pp.* 424-444.

Short descriptions are given of the following mining districts:—1.—*Socorro Mines.* N.E. and S.W. veins of heavy-spar with chloride of silver and vanadium minerals. 2.—*The Magdalenas*, a bold range of metamorphic rocks thirty miles west of Socorro; the *Juniata* lode, carbonate of lead, 40 feet thick. 3.—*The Oscuras Permian Copper Beds.* Deposits of copper-glance, azurite (chessylite), and malachite, also a little silver and gold. 4.—*The Lake Valley or Sierra Mines.* Silver ores (native, chloride, chloro-bromide, and argentiferous galena and lead carbonates), lead (galena, carbonate, and vanadinite), iron (specular or red hæmatite and brown iron ore), manganese (pyrolusite), all veins in Carboniferous Rocks. 5.—*The Black Range.* Gold, silver, copper, zinc, and lead lodes. G. A. L.

GOLD IN DAKOTA.

The occurrence of Gold in the Potsdam formation, Black Hills, Dakota. By WALTER B. DEVEREUX. *Transactions American Institute of Mining Engineers, Vol. X.*, 1882, *pp.* 465–475. *One Figure in text.*

Gold occurs here in a brecciated conglomerate or "cement" at the base of the Potsdam beds, which rests unconformably upon older uptilted schists. The latter are traversed by an auriferous lode known as the Homestake Vein, which is apparently older than the Potsdam beds, and the outcrop of which, though now covered by a sheet of porphyritic trap, is considerably above the level of the "cement" or gold-bearing basement bed of the Potsdam series. This is regarded as a beach deposit, and the gold it contains is supposed to have originated from the Homestake Vein. Placer workings occur in drift due to the waste of the "cement" deposit. G. A. L.

VIRGINIAN IRON ORES.

(1) *The Rich Hill Iron Ores.* By F. P. DEWEY. *Transactions American Institute of Mining Engineers, Vol. X.*, 1882, *pp.* 77–80.

This paper describes the celebrated "car-wheel" iron ore of this region. The Rich Hill ore occurs imperfectly bedded as a sedimentary deposit in Limestone No. 2, which is supposed to be of Trenton age. In amount it is estimated at 2,000,000 tons at least. It is easily accessible, and free from all difficulty from water or otherwise in mining. The percentage of metallic iron, as shown by full analyses given, varies from 51·85 to 57·35, that of phosphorus from 0·050 to 0·200.

(2) *Note on Black Band Iron Ore in West Virginia.* By S. P. SHARPLES. *Ibid, pp.* 80, 81.

Describes a bed of black-band ore, 4 to 5 feet thick, known to occur over a tract of about 1,500 acres at the head waters of Davis Creek, about nine miles from Charleston, West Virginia. Percentage of metallic iron 31·46 to 36·43, of phosphorus 0·25 to 0·87. G. A. L.

PROSPECTING FOR MAGNETIC ORES WITH THE NEEDLE.

De l'emploi de l'aiguille aimantée pour la recherche des minerais magnétiques. By L. PERARD. *Revue Universelle des Mines, etc., Ser. 2, Vol. XII.*, 1882, *pp.* 371–399, *with folding Plate.*

Describes fully the methods followed in North America and in Sweden in searching for magnetic iron ore deposits by means of the magnetic needle, according to Dr. Smock in the former case, and Professor Thalén in the latter. The American *iron hunters* use a needle rotating in a vertical plane only. In Sweden the instrument employed is a declination needle so weighted as to show no dip under the influence of ordinary terrestrial magnetism only, but which dips on being brought near a magnetic mass beneath the surface. A dip needle has now, moreover, been so contrived by Professor Cook as to have a certain amount of horizontal play as well. The geometrical problems involved in the methods described are discussed at length by the author, who also adds some mathematical corollaries of his own. In all cases the ore deposits are regarded as huge magnets, furnished as to each separate mass with N. and S. poles, and having a position (in Sweden at least) generally coinciding with the local magnetic dip.

G. A. L.

THE ST. GENEVIÈVE COPPER DEPOSIT (MO.)

A Review of the Ste. Geneviève Copper Deposit. By FRANK NICHOLSON. *Transactions American Institute of Mining Engineers, Vol. X., 1882, pp. 445–456. Six Figures in text.*

Copper ore was first noticed in St. Geneviève County in 1863. 1.—*The geological formation and modes of occurrence.* The deposit occurs in the second of the Magnesian Limestone series of the Lower Silurian system. The ore is in two nearly horizontal sheets, between strata of chert, in the limestone; it consists of chalcopyrite (massive, 3 inches to several feet thick), chalcocite (never in large quantities), malachite (massive and incrusting), azurite (as an incrustation only), cuprite (in considerable quantities as seams in sulphide), tenorite (not common), chrysocolla (rare). 2.—*Geological history of the deposit.* This is divided into five periods—of deposition, dolomization, dissolution, regeneration, and oxidation respectively. 3.—*Method of working.* Details of the Cornwall mines are given. The cost per ton of the ore delivered at the smelting works, supposing it to carry on the average 18 per cent. of copper, is:—

	Dollars.
Mining and dressing, at 1·50 dol. per cent.	27·00
Supervision, weighing, etc.	0·33⅓
Hauling	2·50
	$29·83⅓

"The market value of such ore, when copper is quoted at 20 cents., is 3 dols. per unit, or 54 dols. per ton. Net profit to owners, 24·16⅔ dols. per ton." G. A. L.

IRON MINES OF ITALY.

L'Industrie minérale en Italie depuis 1860 *jusqu'en* 1880. *By* JEAN BECO *and* LÉON THONARD. *Revue Universelle des Mines, etc., Ser. 2, Vol. XIII., pp. 27–56, with two Maps.*

The chief ores of iron worked in Italy are the magnetite and specular iron ore of the Isle of Elba, and the spathose iron ore (chalybite) of Lombardy. In the present report deposits of secondary importance are described as well, viz., the magnetite of Coigne, in the Valley of Aosta, in Piedmont, which is associated with serpentine, and that of Traversella, in the Chiusella Valley, which occurs as a vein or contact mass lying between diorite and micaschist; little-known deposits (also of magnetite) are known at Strazzema and Forno-Velasco, and others (of hæmatite) at Monte Valerio, Piombino, etc., in the Apuan Alps. Tinstone associated with iron ore has recently been discovered at Monte Fumacchio. Highly manganesiferous ore is worked at the Monte Argentaro Mines, near Porto-Ercole, chiefly for the English market. These contain as much as 30 per cent. of manganese. At the foot of the Tolfa Mountains, 12 or 13 kilometres from Civita-Vecchia, is a large deposit of hydrated peroxide of iron formerly worked. Limonite occurs also in fissure-veins and beds in the limestone mountains of the Central Appenines, at Terra di Lavaro, in the Neapolitan district, and lying between Mesozoic limestones and ancient slates, near Pazzano, in the Calabria. Numerous hæmatite and magnetite deposits are known, and some worked, in the Silurian rocks of Sardinia, as at Acquaresi, Perdastierra, Funtanaperda, S. Leone, etc.

Tables showing the number of mines, number of tons worked, total value in *lires* for each district, and quantity exported for the whole kingdom, are appended. Full analyses of the varieties of Elban ore are also given. The maps show the iron mines of Elba and the adjoining Tuscan coast. G. A. L.

COAL UNDER LONDON.

Examen des études sur l'existence possible de la houille aux environs de Londres. By Ad. Firket. *Revue Universelle des Mines, etc., Ser.* 2, *Vol. XII.*, 1882, *pp.* 457–474.

Gives an analysis of the views published on this subject by Professors J. W. Judd, Prestwich, and Hull, Messrs. T. Audrimont, Godwin-Austen, and others. Compares these with the facts as now known respecting the lie of the Carboniferous rocks in Northern France and Belgium. Concludes that it is probable, from the evidence at present available, that the northern slope (that facing south) of the Coal-Measure trough which apparently extends under the southern portion and further to the south of the Metropolis, begins at about 1,200 metres south of the angle made by Tottenham Court Road and Oxford Street. The author, therefore, advises that a boring be made about 2 kilometres south of that point, but thinks it possible that a great oblique fault similar to that of the Pas-de-Calais (the *Grande-faille*) may be present, and may cause here also an apparent reversal of the order of the rocks, *i.e.*, that Devonian or Carboniferous limestone may overlie the Coal-Measures. G. A. L.

IRON AND COAL OF CHINA.

Les Mines de Fer et de Charbon en Chine. By Count de Noidans-Calf. *Revue Universelle des Mines, etc., Ser.* 2, *Vol. XII., pp.* 478–482.

An official report to the Belgian Minister of Foreign Affairs from the Belgian Resident Minister in China. A brief account of the mineral resources of the Northern Provinces of Tchihli and Shantung. Analyses by Dr. Percy are appended (1) of brown iron ore containing 53·33 *per cent.* of metallic iron, no sulphur, and only 0·15 of phosphoric acid; (2) of coal of excellent quality. Both iron and coal come from Pung-tchung in the district of Taming-Fou, and occur in large quantities. Copper and lead mines are also referred to. G. A. L.

SILVER ORES OF THE ANDES.

Analyses de minerais argentifères de la Cordillière des Andes. (Mine del Doctor, près de Mexico) [sic]. Revue Universelle des Mines, etc., Ser. 2, *Vol. XII., p.* 483.

Analyses:—(1) Of vein ore showing crystals of pyrite, calcite, quartz, and stibnite, yielding 1,250 grammes of silver to the ton; (2) of three samples of yellowish-grey alluvial sands, yielding 2,600, 550, and 2,800 grammes of silver per ton respectively. G. A. L.

COALS OF ITALY.

L'Industrie minérale en Italie depuis 1860 *jusqu'en* 1880. *Part II. By* Jean Beco *and* Léon Thonard. *Revue Universelle des Mines, etc., Ser.* 2, *Vol. XII.*, 1882, *pp.* 114–142.

This part of the memoir comprises a summary of the official statistics as to the existence and commercial value of the various fossil fuels of Italy. Of these only a few seams of anthracite belong to the Palæozoic series. They are known at fifteen points, of which the principal are:—La Thuile, in the Valley of Aosta, where six seams one metre thick are known to occur over a small area, and are worked for local use; Monficis and Calizzano, in the Maritime Alps, where the seams are poor; Cludicino and Creta d'Oro, near the Carinthian frontier, where the anthracite is too friable and otherwise useless for general purposes; Monte Jano, in Tuscany, with one

worthless seam of true Carboniferous age; Seni, in Sardinia, where there is a small basin containing a seam 2½ metres thick, but so situated as regards communications, etc., as to render its working extremely costly.

The lignites, on the other hand, are abundant, and distributed over seventy-two distinct districts. The basins recognized in 1880 as being economically important may be thus enumerated:—

1.—*Monte Pulli*, in the Agno Valley (Province of Vicenza).—Age, Eocene. Nine seams of lignite with a total thickness of 9 metres, and three beds of bituminous shale. Annual production, 12,000 tons. Estimated workable amount remaining in 1880, 400,000 tons. Quality very good; used at the Venice Arsenal and by the Lake Garda steamers.

2.—The *Gonesse* Basin, in Sardinia.—Age, Eocene. Three or four seams, with a total thickness of 2 to 3 metres. Annual production, 14,000 tons. Estimated workable amount left in 1880, 5,500,000. Quality very good; used at the adjoining lead mines of Monteponi, San Giovanni, and others.

3.—*Cadibona*, in the Province of Genoa.—Age, Miocene, lacustrine. One principal seam 2·50 metres thick. Production in 1878, 4,800 tons. Nearly exhausted. Quality excellent; used for navigation.

4.—*Garbenne*, near Nuceto, in the Province of Cuneo.—Age, Miocene, lacustrine. One seam 0·60 to 1·00 metre thick. Annual production, 2,000 tons. Quality, a rather friable lamellar lignite.

5.—*Sarzana*, near La Spezzia (Province of Genoa).—Age, Upper Miocene. One seam 2 to 2·50 metres thick. Annual production, 15,000 tons. Amount left in 1880, 600,000 tons. Quality good; used in the lead smelting mills at Pertugola.

6.—*Monte Massi and Tatti*, in the Province of Grosseto.—Age, Miocene, marine. Four seams, 6·00, 1·20, 0·80, and 1·90 metres (in descending order). Annual production, 11,000 tons. Amount left in 1880, 15,000,000 tons. Quality good when washed; used on the railways.

7.—*Monterufoli*, in the Province of Pisa.—Age, Lower Miocene, lacustrine. Two seams, each 1 metre thick. Scarcely worked. Amount available, 400,000 tons. Quality poor and friable; useless for locomotives unless mixed with other coal.

8.—*Murlo*, Province of Sienna.—Age, Lower Tertiary (Eocene?). Three seams 1 to 6 metres thick. Annual production, 4,000 tons. Amount left in 1880, 700,000 tons. Quality second rate, but used on the railway.

9.—*Castelnuova*, in the Val d'Arno (Province of Arezzo).—Age, Upper Tertiary. Thick beds, sometimes 25 metres or more. Annual production, 40,000 tons. Amount left in 1880, 20,000,000 tons. Quality, a brown woody lignite, requires drying, but can be used for locomotives.

10.—*Spoleto*, Province of Perugia.—Age, Upper Tertiary. One seam only, 8 metres thick. Scarcely worked yet. Amount available, 1,000,000 tons. Quality, a woody lignite.

11.—*Val Gandino*, Province of Bergamo.—Age, Upper Tertiary. Several seams, of which one only, 8 metres thick, is worked. Annual production, 8,000 tons. Amount left in 1880, 5,000,000 tons. Quality like that of the Val d'Arno (No. 9); used in various local factories.

12.—*Garfagnana*, Province of Massa-Carrara.—Age, Upper Tertiary. Seams not yet worked in 1880. Amount available, 2,000,000 tons. Quality woody, but often block lignite.

To these lignite basins four to five million tons of good workable peat must be added.

G. A. L.

MINERAL OILS OF CENTRAL EUROPE.

Notice sur les gisements pétrolifères de l'Europe Centrale et étude spéciale des gisements du Nord de l'Allemagne. By L. PIEDBŒUF. *Revue Universelle des Mines, etc., Ser. 2, Vol. XIII., pp.* 57–76, 611–654, *with Four Maps.*

The principal oil-regions of Central Europe are:—The great plain of North Germany, extending over Hanover and part of Brunswick; the western portion of the plain of the Upper Rhine, from Worms to Bâle, at the foot of the Eastern Vosges; and in the Carpathians—on their northern slopes towards Galicia, and on their southern towards Hungary. In these three districts traces of oil are found in all the permeable rocks of recent, Tertiary, and Cretaceous age, of which the surface is formed. Besides these larger oil-bearing tracts several other occurrences are known. In the Tyrol the St. Quirin oil-well, on the banks of the Tegernsee, has been worked for centuries for medicinal purposes. Other springs of the same kind have been discovered in Northern Italy, in the neighbourhood of Bologna, and many in Roumania. The well-known asphalt deposits in Western Switzerland are perhaps an indication of the presence of petroleum.

The concluding part of the paper gives a detailed description of the oil deposits of Limmer, near Hanover and Sehnde, to the south of Lehrte; Wietze and Steinförde; Oelheim, Oedesse, Edesse, and Fissenberg; Oberg and Oelsburg; of Alsace and the Upper Rhine Valley. A more general account, condensed from Strippelman's work on the subject, is given of the Galician deposits. The general conclusion arrived at by the author in every case is that the oil comes originally from the beds of Middle and Upper Trias, the Muschelkalk and Keuper, whatever be the geological age of the overlying rocks in which it is now found. Pages 637 to 654 are devoted to proving this point on geological and especially on chemical grounds. The latter lead to the belief that the petroleum is due to the decomposition of the animal organic matter which must have been present in vast quantities in the thick shell beds of the Middle Trias—the Muschelkalk. G. A. L.

BRAZILIAN DIAMONDS.

Sur les Gîtes diamantifères du centre de la province de Minas-Geraes, Brazil. By PROFESSOR GORCEIX. *Bulletin de la Société Géologique de France, Ser.* 3, *Vol. X., pp.* 134, 135.

At Cocaës (60 kilometres north of Ouro-Preto), Conceicão, and Diamantina, diamonds are found in alluvial deposits associated with rolled fragments of Titanium oxides, ilmenite, tourmaline, quartz, hydrated chloro-phosphates, iron glance, fibrolite, altered pyrites, disthene, manganese oxides, magnetite, etc. All minerals found associated together in quartz veins belonging to the earlier group of quartzites of the region (Pre-Devonian). Diamonds are themselves found in these quartzites.

At San Joan du Chapada, 30 kilometres west of Diamantina, diamonds are worked in beds of clay which alternate with green-mica quartzites. In this locality the diamonds are undoubtedly *in situ*, and show no trace of wear. G. A. L.

MANGANESIFEROUS IRON ORE IN THE PYRENEES.

Rapport sur les mines de fer oxydé manganésifère d'Escoumps, Commune de Nyer (Pyrénées-Orientales). By THEODORE VIRLET D'AOUST. *Paris*, 1882, *4to*, 12 *pp*. *One Plate.*

A report on the Escoumps manganesiferous hæmatite mine. This is one of a belt of iron mines skirting the base of the Canigou range. They are not, as Dufrénoy stated, associated with granite. On the contrary, the ore-bearing veins occur in one of the calcareous zones of the Silurian. Granite occurs only some distance south of Nyer.

G. A. L.

COAL ON THE KISTNA (INDIA).

Note on the supposed occurrence of coal on the Kistna. By H. B. MEDLICOTT, M.A. *Records of the Geological Survey of India, Vol. XV., pp.* 207–216.

Since 1850, the reputed discovery of coal near Jaggayapet, in the Kistna district of Madras, has been repeatedly brought to the notice of the Government. The full details of the history of this supposed find by General Applegarth, and of the subsequent enquiries into the matter, are given in this official report to the Governor of Madras. It is clearly shown that no coal has been proved to occur in the locality, and that the rocks there are such—of transition or Lower Vindhyan age, and therefore much older than any of the coal-bearing formations of India—as to preclude any hope of any being found. A note at the end of the paper (p. 216) states that the Government of Madras has finally decided not to re-open the question.

G. A. L.

INDIAN IRON ORES.

On the Iron Ores and Subsidiary Materials for the Manufacture of Iron in the North-eastern Part of the Jabalpur District. By F. R. MALLET, F.G.S. *Records of the Geological Survey of India, Vol. XVI., pp.* 94–115, *with a Map.*

The workable iron ores of this region are thus classified by the author:—

BIJÁWAR ORES ...	1. *Hæmatite* ...	... Schistose hæmatite. Micaceous iron ore. Jasper hæmatite. Semi-ochreous hæmatite. Manganesiferous hæmatite.
	2. *Limonite.*	
LATERITE ORES ...	1. *Limonite* ...	... Pisolitic limonite. Ordinary laterite, sometimes rich in iron.
	2. *Hæmatite.*	

The necessary fluxes for smelting the ores are present in the Lower Vindhyan limestone, the Lameta limestone, and an aluminous variety of laterite. Dolomite is also abundant, and would be useful for lining converters, should the occurrence of manganesiferous ore suitable for the production of spiegeleisen lead to Bessemer steel-making and the adoption of the basic process. Fire clay is also known in the region.

The report concludes by urging the advantages of Murwára as a site for future ironworks.

Analyses of the ores and fluxes are given.

G. A. L.

THE UMARIA COAL-FIELD (INDIA).

Further Notes on the Umaria Coal-field (South Rewah Gondwana Basin). By THEO. W. H. HUGHES, A.R.S.M., F.G.S. *Records of the Geological Survey of India, Vol. XVI., pp.* 118–121.

Reports progress as to boring and shaft-sinking to prove the seams of this coal-field. Two seams, 10 feet and 6 feet thick, were passed through in a boring (No. 9), and another of good quality is being worked by means of an incline. This seam is 4 feet 8 inches thick. The shaft had only reached a depth of 40 feet, and had not yet struck coal. Sections of No. 9 bore and of the seam worked are given. G. A. L.

MINERAL RESOURCES OF MANIPUR AND NAGA HILLS.

Report on the Geology of parts of Manipur and the Naga Hills. By R. D. OLDHAM, A.R.S.M., *Memoirs of the Geological Survey of India, Vol. XIX., pp.* 217–242. *One Plate and three Maps.*

This region was all but unknown, as regards its geology, before the exploration of which this is the report. Although it is some 1,800 square miles in area, it is poor in minerals of economic importance. The following, however, are recorded:—

Iron.—Occurs as a workable pisolitic limonite (bog iron ore), intermixed with clay in the swampy alluvial bogs of the district. South of Thobal, titaniferous iron ore is stated to be present in the stream deposits. A description of the iron furnace in use by the natives in Manipur is given.

Copper.—"Is worked in the south-east corner of Manipur territory, the ore being obtained from the hills bordering the Kubo Valley."

Gold.—"Is worked in the sands of the Ningthi River."

Salt.—Is tolerably abundant and is worked by means of brine wells.

Edible Earth and a very scanty supply of *Limestone* for lime burning complete the list of economic mineral deposits. G. A. L.

CRETACEOUS COALS IN THE KHASIA HILLS.

Note on the Cretaceous Coal-Measures at Borsora, in the Khasia Hills, near Laour, in Sylhet. By TOM D. LA TOUCHE, B.A. *Records of the Geological Survey of India, Vol. XVI., pp.* 164–166.

A section of 150 feet of sandstone, including three seams of coal (four, three, and three feet thick respectively), is described as occurring beneath the Nummulitic limestone, at the foot of the Khasia Hills. The coal is of excellent quality, and is very favourably situated for winning. Two analyses are given as follows:—

	Seam No. 1.	Seam No. 2.
Moisture	5·84 ...	3·02
Other volatile matter	35·16 ...	39·58
Fixed carbon	50·40 ...	50·80
Ash	8·60 ...	6·60
	100·00	100·00

The age of the coal-bearing beds is Cretaceous and the same as that of the Garo Hills and the small basin of Maobelarkar, but distinct from that of the Cherra-Poonjee coal. G. A. L.

GOLD-FIELDS OF MYSORE.

Notes on a Traverse across some Gold-fields of Mysore. *By* R. BRUCE FOOTE, F.G.S. *Records of the Geological Survey of India, Vol. XV., pp.* 191–220, *with Section and Map.*

The geology of the region traversed consists essentially of a few north and south folds of schistose rocks overlying and squeezed in between the general granitic mass which forms the prevailing rock of the country. The gold-fields coincide with the schistose bands, and are (in order from east to west):—1.—The Kolar gold-field band, which is the best known, most fully described in this paper, and that containing most reef-working gold mines. 2.—The Dambal—Chiknayakan-halli band, comprising the Dambal gold-field, where gold occurs both in reefs and in the superficial deposits. 3.—The Dharwar-Shimoga band, in which the schists are chloritic, interbedded with quartzites and associated with very thick and coarse conglomerates (the "great conglomerates" of Kal Drug, Phillur Gudda, and Kalva-Ranganbetta). The Honnali gold-field is situated among this chloritic schist and quartzite series, and comprises a large number of important quartz-reefs, whence the gold in the thick red soil of the low ground is derived.

Intrusive trap-rocks occur in the Kolar schists, and will prove formidable obstacles to reef-mining in some parts of that field. G. A. L.

SULPHUR IN THE CAUCASUS.

Giacimenti solfiferi del Caucaso e loro confronto con quelli di Sicilia. *By* L. BALDACCI. *Bolletino del R. Comitato geologico d'Italia, Ser.* 2, *Vol. IV., pp.* 15–20.

The sulphur deposits described are worked on the Khioutt Mountain, about 70 kilometres from the port of Petrowsk, on the Caspian Sea, and 47 from Temir-Khan-Tschura, in Daghestan, and not far from the confluence of the Rivers Koison d'Andii and Avare. They lie about two-thirds of the way up the mountain, at a height of 1,700 metres. The strata are very regular and their succession is very distinct on the steep slope of the mountain. The sulphur bed is, on an average, 1·60 metres thick, and occurs among limestones and marls of Lower Cretaceous (perhaps Gault) age. Gypsum is also associated with the deposit.

Baku, the great centre of petroleum production, is the market to which the sulphur is brought, 6,000 barrels being used there per annum for the manufacture of sulphuric acid used in refining the mineral oils. The extent of the deposit at Khioutt limits the local production of sulphur to about this amount which, the writer points out, is barely one-fiftieth of the sulphur output of Sicily. G. A. L.

COPPER DEPOSITS OF ITALY.

Sui giacimenti cupriferi in Italia. *By* DR. ED. REYER. *Bolletino del R. Comitato geologico d'Italia, Ser.* 2, *Vol. IV.,* 1883, *pp.* 34–38. *See also Berg- und Hüttenmännische Zeitung for* 1882, *No.* 49.

The copper ores of Italy are found associated with the basic eruptive rocks of Upper Cretaceous and Tertiary age. They occur in four positions:—1.—Disseminated in the eruptive mass. 2.—In veins in the trap. 3.—As contact veins between different eruptive masses. 4.—As contact veins between trap and sedimentary rocks. Deposits of the second, third, and fourth kinds are often much dislocated, and those veins which are brecciated are particularly rich. G. A. L.

RUSSIAN PEAT.

La Tourbe, son exploitation et son emploi industriel. By GEORGES DE CUYPER. *Revue Universelle des Mines, etc., Ser.* 2, *Vol. XIII., pp.* 518–551.

Peat deposits occur in Russia in forty-five Governments, and occupy a workable area of about 100,000 square versts. The Governments of Moscow, Novgorod, Riazan, Nijni-Novgorod, Orel, and some few others in the south, are those in which it is most prevalent. The methods of working the turbaries adopted at Koulebaki, in the Ardatof district, are described, and details given as to composition, cost, economic value for railway purposes and others. The following comparative table, amongst others, is given:—

Fuel.	Price in Roubles and Kopeks per 100 Kilogrammes. R. K.	Heating power of 1 Kilogramme in Heat Units.	Price of 100,000 Heat Units. Kopeks.
Anthracite	1·20 ...	6,300 ...	19
„	1·02 ...	5,500 ...	18½
Coke	·84 ...	4,700 ...	17 8/10
Wood	·54 ...	2,800 ...	19 3/10
Peat	·66 ...	3,800 ...	17 8/10

The paper forms part of a Report on the 1882 National Exhibition of Moscow.

G. A. L.

NAPHTHA AND ITS PRODUCTS.

Le Napthe et ses Produits. By GEORGES DE CUYPER. *Revue Universelle des Mines, etc., Ser.* 2, *Vol. XIII., pp.* 552–563.

This paper also forms part of a Report on the 1882 National Exhibition of Moscow. The principal deposits of naphtha in Russia are in the Taman Peninsula, in Daghestan, in the Peninsula of Apcheron, in the Kouban, in the island of Tchelekenne, in the country round Chamakhi, Chanchi, and Tiflis, all along the line of railway beyond the Caspian. There are fewer naphtha springs in the interior of Russia, but some are known in the Governments of Samara, Simbirsk, Kazan, and others. In 1877 the production of naphtha reached 15,000,000 pouds, at half a kopek per poud. In 1877 the figures are 37,000,000 pouds, at two kopeks.

The products of naphtha are:—

		Deg. C.
Cymogene, a kind of ether	with boiling point at	0
Rhigolene, a less volatile substance	„ „	18
Light oils (including *Benzine, Astraline*, etc.)	„ „	15 to 120
Kerozene (refined petroleum)	„ „	120 to 300

Lubricating oils.

Paraffine, used chiefly for candle-making.

Vaseline.

Coke, possessing great heating power, and burning as well as the best coals.

G. A. L.

MINERAL STATISTICS OF RUSSIA AND FINLAND.

Statistique de l'Industrie minérale en Russie et en Finlande, 1881–82. ANON. *Revue Universelle des Mines, etc., Ser. 2, Vol. XIII.*, 1883, *pp.* 664–667.

Reproduces the following results of the official reports respecting the mineral production of Russia during the year 1881–82 (from May, 1881, to May, 1882). The weights are given in *pouds* (1 pond = 16·38 kilogrammes):—

			Showing, when compared with 1871–72.
Gold		2,244	a decrease.
Platinum		182	an increase.
Silver		576	"
Lead		60,218	a decrease.
Copper		211,465	"
Zinc		277,641	an increase.
Tin		604	"
Iron		58,073,554	"
Coal—			
Donetz,	91,298,166		
Poland,	85,774,707		
Moscow,	23,426,204		
Urals,	10,031,292		
Other basins,	2,728,108		
		213,258,477 ...	an increase of more than 300 per cent.
Naphtha		40,474,731	an increase of 4,000 "
Petroleum		12,840,657	" 2,400 "
Chromite		150,349	a decrease.
Manganese ore		686,106	an increase.
Sulphur		6,479	"
Salt		50,734,355	"
Glauber's salts		106,335	"

G. A. L.

COALS OF ISTRIA AND DALMATIA.

Note sur certains combustibles tertiaires de l'Istrie et de la Dalmatie. By — LODIN. *Annales des Mines, Ser. 8, Vol. III.*, 1883, *pp.* 209–233.

The lignites worked in Dalmatia belong to the Upper Nummulitic zone, and are therefore of Eocene age. The chief localities are Monte-Prima, near Dernis, where a seam 8 or 9 metres thick, on an average, is worked in a small way; Dubrovizza and Velikaglova, where six seams are known, of which two only (2·20 and 1·40 metres thick respectively) have yet been worked. In all three localities the lignite produces only 3 to 6 per cent. of ash, but contains as much as 17 per cent. of sulphur.

The Istrian localities are:—Albona, where the lignite occurs at the base of the Eocene, immediately overlying the Hippuritic Limestone of the Cretaceous, and where three seams of very variable thickness, reaching in each case from 3 to 4 metres, are worked; Brittof and Skofle, with two or three seams of similar character. The analyses of these lignites which are given show 30 per cent. of volatile matter, 65 2 of fixed carbon, 9·8 of sulphur, and 2·1 of ash. Its coke is of remarkable hardness.

About 50,000 or 60,000 tons of these lignites are worked yearly, their market being Fiume, Pola, Trieste, Venice, Ancona, and other Adriatic ports. G. A. L.

SEO DE URGEL COAL-FIELD (N. SPAIN).

Carbon de la Seo de Urgel. Revista Minera y Metalúrgica, Ser. C., Vol. I., 1883, *p.* 255.

Brief account of the Navinés coal deposits, at the foot of the southern or Spanish slope of the Pyrenees. 50,000,000 tons of workable coal are said to be available in the neighbourhood of the Seo de Urgel mines. The coal is a dry anthracite, free from sulphur, burning with a short flame, and having a calorific power of 7,000. A fuller account of this coal-field, entitled "Cuenca carbonifera de Seo de Urgel," has been published by DON LUIS MARIANO VIDAL, 8vo, with plates; *Barcelona*, 1883.

G. A. L.

THE MINING REGION OF MAZARRON.

La Comarca minera de Mazarron. By E. R. C. *Revista Minera y Metalúrgica, Ser. C., Vol. I.*, 1883, *pp.* 132-135.

A brief general account of the metalliferous resources of this part of Spain. Occupying a belt of country some ten kilometres in breadth, and extending from the coast at Carthagena to the interior of the province of Almeria, is a network of veins rich in iron, lead, silver, and aluminous minerals. These veins run in four principal directions, were formerly largely and profitably worked, and the author deplores the want of enterprise which, he considers, alone prevents their being still more extensively opened out at the present day. The amount of ore still available is probably, he states, very large, and only needs thorough exploration. The veins are intimately connected with eruptive masses of porphyrite, diorite, serpentine, trachyte, and basalt, intruded amongst the Palæozoic rocks which form the stratified framework of the region.

G. A. L.

INDICATIONS OF PETROLEUM.

Yacimiento del petróleo. By — GAUSSOIN. *Revista Minera y Metalúrgica, Ser. C., Vol. I.*, 1883, *p.* 239.

The following are given as the indications most relied on for detecting the presence of petroleum in Canada and Pennsylvania :—

1.—Proximity of volcanic mountains and presence of some important streams.
2.—Flora of salt soils.
3.—Existence of the Upper Coal-measures.
4.—Presence of sulphurous and salt veins.
5.—Emanations of carbonic acid, sulphuretted hydrogen, and other gases of more complex composition.
6.—Iridescent waters at all temperatures, and during summer the surface of ponds covered with greasy matter.
7.—Lastly, the presence of bituminous substances in a viscous state.

The above are said to be, in the countries named, the *constant* signs of petroleum.

G. A. L.

COBALT AND COPPER ORES OF LEON.

Criaderos de Cobalto y Cobre en las inmediaciones de Villamanin, Provincia de Leon. *By* R.[AMON] A.[DAN] DE Y.[ARZA]. *Revista Minera y Metalúrgica, Ser. C., Vol. I.*, 1883, *pp.* 358–359.

The ancient kingdom of Leon is rich in limestone rocks of Devonian age. Much of this limestone is altered into dolomite, and this metamorphism has taken place in directions parallel to the strike, as if it were due (as the author believes) to magnesian thermal springs making their way upwards along the planes of bedding. This action was, it is shown, accompanied in certain localities by the deposition of metalliferous ores. Thus the dolomitic zone, situate to the north of the Villamanin Station on the North-Western Railway, and which can be traced for many miles running E. 20° S. and W. 20° N., and coinciding with the strike of the beds, is marked by the constant outcrop of rock showing more or less blue and green carbonates of copper and black oxide of cobalt in the form of dendrites. The richness of the impregnations varies greatly, from a mere trace to 30 per cent. of almost pure grey copper ore. The La Profunda Mine is working these deposits. G. A. L.

IRON ORES OF BISCAY.

Criaderos de hierro de Vizcaya. *By* IGNACIO GOENAGA. *Revista Minera y Metalúrgica, Ser. C., Vol. I.*, 1883, *pp.* 296–299, 311–314, 328–329, 339–341, 355–358.

The iron-mining region of Biscay is divided by the author into eight districts which are described in the following order:—(1) Sommorostro; (2) Galdames; (3) Sopuerta; (4) Regato; (5) Abando; (6) Ollargan; (7) Galdácano; and (8) Guernica-Luno. Geologically, all the iron ores occur in the Cenomanian division of the Cretaceous series. They are generally believed to have been deposited by hydrothermal agency, the siderites having been formed first, then the red hæmatite from the last, and lastly the remarkable alluvial ores of the country derived from the others. The whole region, says the author, may be regarded as a single vast deposit of iron ore, subdivided into different parts, and cropping up at innumerable points at the above-mentioned horizon.

The different varieties of ore worked in each district, and the methods of working them are described, and statistics of production are given. G. A. L.

BELMEZ COAL MINES (SPAIN).

Minas de Cabeza de Vaca, en Belmez. *By* FRANCISCO CROOKE LORING. *Revista Minera y Metalúrgica, Ser. C., Vol. I.*, 1883, *pp.* 478–481, 495–496, 507–522.

The Cabeza de Vaca Collieries have been open since 1790. They are worked to a depth of 150 metres, being 50 metres deeper than any of the other mines in the coal-field. Four seams are sunk through, about 50 metres apart from one another, and dipping about 72 deg. to the south-west. Of these seams the first and fourth only are worked. The workings in No. 4 extend for a distance of two kilometres, varying in thickness, but five metres on an average. The other seam is more irregular, thickening and thinning so as to form a succession of lenticular masses, with an average of 5·5 metres. There are three pits.

The methods of working are very fully described. G. A. L.

CALIFORNIAN CINNABAR DEPOSITS.

Los criaderos de cinabrio de California, Nevada y Virginia. *By* RAMON ADAN DE YARZA. *Revista Minera y Metallúrgica, Ser. C., Vol. I.*, 1883, *pp.* 87–89.

Sulphide of mercury occurs in California as impregnations chiefly in the rocks forming the Coast Range—a zone of highly metamorphic beds of Palæozoic, Cretaceous, and Lower Tertiary age, broken through by eruptive masses of serpentine, trachyte, basalt, and other igneous rocks. In the neighbourhood of the more recent volcanic matter geysers, solfataras, and other gaseous and hydrothermal emanations are frequent. The Cinnabar impregnates any of the rocks of the country indifferently, sometimes forming horizontal masses simulating beds, sometimes lenticular in shape, sometimes occurring in stockwerk form. The deposits at Nuevo Almaden, South of San Francisco, occur about the junction between eruptive serpentine and Cretaceous beds. At Redington Mine, about 70 miles north of San Francisco, the cinnabar is found along a similar junction, but is remarkable for its association with large masses of opal, hyalite, and other peculiar forms of silica. In this mine, also, much carbonic acid gas is given off. The Sulphur Bank deposits, near Clear Lake, further to the north-west from San Francisco, are closely connected with recent volcanic ejections, thermal springs, solfataras, and gas emanations. In the vicinity of the mines the vegetation is incrusted with sulphur and cinnabar. Here again opal and chalcedony accompany the mercury, as well as sulphur and bituminous minerals. At Sulphur Springs, north-east of Borax Lake, cinnabar is found under very similar conditions, but associated with silver and gold.

The geyserian phenomena exhibited in Steamboat Valley, on the eastern slope of the Cordillera of Virginia, eight miles north-west of the town of that name, are described, and the view which connects the cinnabar impregnations with hydrothermal action is entertained by the author as the most probable of the theories advanced to account for their origin. G. A. L.

THE ALMERIA LIMESTONE ORE DEPOSITS.

Criaderos metaliferos en la caliza de Almeria. *By* JUAN PIÉ Y ALLUÉ. *Revista Minera y Metallúrgica, Ser. C., Vol. I.*, 1883, *pp.* 341–345.

The ore deposits of this district are well represented by the lead ores of Sierra de Gador. They are very peculiar in many respects, being neither veins proper nor truly bedded ores. They occur in the limestone only (which is of Triassic age), being limited below by the underlying slates in which they are not found. They have a very low dip, often crop out at the surface, and when they do not are directly connected with it by a system of small fissures or cracks. They are very irregular, thinning and thickening within short distances, and occasionally swelling into pockets (*bolsadas*) of enormous dimensions. They are not accompanied by ordinary veinstuff, spar, etc., but by a sandy earthy breccia or conglomerate. When the ore is galena it is very free from silver. There is a distinct parallelism between the deposits and the shape of the country.

The author attempts to explain the peculiarities above enumerated and sundry others of minor importance, by the supposition that the ores were deposited by mineral springs in cavities (caverns) previously worn out of the limestone by the percolation of surface water in the ordinary way, the deposition or precipitation being due to the sudden release from pressure and heat undergone by the thermal water on ascending from lower regions. This theory, he states, is consistent with all the facts observed in these singular accumulations of ore. G. A. L.

ON THE DURHAM COLLIERY EXPLOSIONS IN THE FIRST MONTHS OF 1882.

Note sur les explosions de grisou survenues dans le bassin de Durham pendant les premiers mois de 1882. *Par* M. C. WALCKENAER, *Ingénieur des Mines. Annales des Mines, Ser.* 8, *Vol. III.*, 1883, *pp.* 247–289.

Fire-damp, says the author, continues to be fatal in England. In two months (16th February to 19th April) the Durham coal-field witnessed three explosions, resulting in 119 deaths, and these are investigated as follows:—

1.—TRIMDON GRANGE EXPLOSION, 16TH FEBRUARY, 1883.

The accident occurred in the Harvey Seam, and a plan is appended (Plate III.) showing the mode of working to be "long-wall." The large number of doors (viz. 52, with 6 regulators and 4 crossings) is pointed out, as well as the stoppings, etc., and the communication with East Hetton described. Ventilation was effected by furnace, and gave a total volume in the Harvey Seam of 44,750 cubic feet per minute. The seam was moderately fiery and very dusty, the roads being watered where absolutely necessary; Davy lamps were alone used. Although the barometer and thermometer did not appear to have had much influence at the time of the explosion, it was observed that the roof had become very bad prior to the explosion. Death, in all but 15 or 16 cases, appears to have been the result of after-damp, the total number of victims being 69. After examining carefully the different theories propounded at the inquest and in the subsequent official reports, the author submits his own conclusions, and confesses himself unable to agree with the evidence at the inquest suggesting concurrences in a fall, a sudden outburst, and an open light, and he inclines rather to blame the system of ventilation, by which the destruction of crossings, doors, and stoppings increases the propagation of the fire, and tends to aggravate the succeeding effects of after-damp.

These conclusions are practically repeated in the second part of his article, viz.:—

2.—TUDHOE (18TH APRIL, 1882).

With the addition of his objection to mixed, open, and safety lights in a fiery mine, even where the former are only used in the main intakes, and to professional evidence when tendered on behalf of owners. In this case (see Plate IV.) the ventilation was mechanical, and is described as ample. The Brockwell seam was the seat of the explosion, which occurred in the night shift, 22 being killed by burning and 15 by after-damp. The mine is described as not very fiery, but very dry and dusty.

3.—WEST STANLEY (19TH APRIL, 1882).

Here the explosion occurred in the Busty Seam (Plate V.) The ventilation was effected by a 30-foot diameter Guibal, the split in the Busty Seam being nearly 24,000 cubic feet per minute. The presence of gas had frequently been ascertained, but the author describes as careless the mode of detecting it. The explosion occurred at 1 a.m., and the ventilation is then stated as good and the lamps apparently in order. 13 perished, all more or less burnt. The conclusions arrived at in this case by the author are, that probably two of the men at work being alarmed by seeing or hearing gas in their places rushed with their lamps through an explosive atmosphere, and thus passed the flame. He again mentions the caution with which professional evidence should be received, as it often has a tendency to screen, by attributing to sudden outbursts or some other convenient plea, the faults of the mode of laying out or working the pit.

M. WALCKENAER gives his general summary and review of the causes of explosions in English mines at great length, and amongst many other points criticised by him, we find the disparity in area between the intakes (engine planes and rolleyways) and the restricted and tortuous returns, the length of the splits, and the incomplete separation of districts and panels.

D. P. M.

ON SAFETY-LAMPS; NOTES ON M. MARSAUT'S EXPERIMENTS.

Sur les lampes de Sureté à propos des récentes expériences de M. MARSAUT. *Par* MM. MALLARD *et* LE CHATELIER. *Annales des Mines, Ser.* 8, *Vol. III.*, 1883, *pp.* 35–68.

M. Marsaut, engineer of the Bessèges collieries, has recently published his account of his own experiments on safety-lamps, in which he has stated that a Meuseler lamp reversed will, even in *still* gas (*i.e.* inflammable mixture), communicate flame to the surrounding atmosphere.

Having been requested by the Government to investigate his experiments, the writers submit the following notes:—

PROPAGATION OF FLAME THROUGH GAUZE.

It is well known that the resistance of metallic cloth or gauze to the passage of flame is in inverse ratio to the velocity of the current of air *fanning* the flame; also that the more the number of openings is diminished the higher the velocity of such air will be through the meshes still accessible. This velocity may be designated by V, and depends upon the area of the meshes of the gauze and the mixture of air and gas. It has been found by experiments that pit gas requires a higher velocity than ordinary illuminating gas, in the proportion of 1·4 to 1. If the velocity of the air current exceeds V, when the inflamed mixture reaches the wire gauze inflammation is at once communicated to the surrounding atmosphere.

These principles applied to safety-lamps demonstrate that when such a lamp containing pure air is suddenly carried into an explosive mixture (the latter in a state of repose) the explosive mixture takes the place of the pure air either by diffusion or by the movement of the lamp itself. This mixture is ignited by the flame of the lamp, and will not communicate with the outside unless the proportion of gas and air is of the most explosive nature. Should this be the case, the sudden expansion of the flame will force its way through the gauze independently of external velocity. If the lamp is gradually raised into an explosive medium the top of the lamp may fill while the oil flame still burns with fresh air until contact ensues, and the force of the explosion may also cause the flame to pass through the meshes of the gauze. These points were not much considered until M. Marsaut directed the attention of miners to them.

The apparatus designed by M. Marsaut for the purpose of proving these principles is illustrated (Plate I., Figs. 9, 10. and 11) and a full description given. It has the advantage of testing lamps under conditions nearly similar to those which might be expected in working use, but it, at the same time, does not permit of a constant condition in each several experiment.

That designed by the authors is intended to obviate the defect last alluded to, and has answered well, being easily performed and understood. The results obtained on different lamps are given and summarised. The *Meuseler* being, when properly constructed, practically safe. The *Boty* lamp is considered as inapplicable to workings in fiery mines, and is especially unsafe with the addition of a chimney. The *Davy*, according to the authors, should be peremptorily dismissed, although the type as modified by Dubrulle does not explode so rapidly. The *Marsaut* lamp is considered safe with double or triple wire gauzes, but is too easily extinguished.

In conclusion it is suggested that the Davy lamp might be so shielded as to prevent external currents from affecting any internal ignition of explosive atmosphere, and this has already been done in our own district. D. P. M.

NEW MODE OF WORKING AND LOCKING SWITCHES BY A SINGLE LEVER.

Note sur un nouvel appareil pour Manœuvre et Calage des Aiguilles de Changement de Voie, par un Seul levier système Dujour. Annales des Mines, Ser. 8, *Vol. III.*, 1883; *pp.* 80–84.

When railway switches are placed at some distance from the levers it becomes impossible to ascertain by sight whether they are working properly, and even the latest improvements, such as those of Saxby and Farmer, still necessitate a double arrangement of levers, etc.

The apparatus designed by M. Dujour permits of acting by one single movement on the switch, the bolt, and the locking bar, and hence results economy in first cost and in the time of the signalman. The details of the apparatus are minutely described and figured (Plate II., Figs. 1–8). The railway from Paris to Lyons and the Mediterranean has adopted the system with great success. The prime cost is given at 200 fcs. (£8) as compared with 340 fcs. (£13 12s.) in Vignier's system, and 370 fcs. (£14 16s.) in the Saxby. D. P. M.

ON ACCIDENTS FROM FIRE-DAMP IN PRUSSIA FROM 1861–1881.

Les Accidents de Grisou arrivés en Prusse de 1861 *à* 1881. *Par* M. Hasslacher, *Conseiller royal des Mines à Berlin au nom de la Commission de grisou. Extrait par* M. G. Chesneau, *Ingénieur des Mines; Annales des Mines, Ser.* 8, *Vol. III.*, 1883, *pp.* 445–462.

Following the example of the French Committee on Prevention of Accidents from Fire-damp, a Prussian Committee was formed to tabulate systematically such accidents in Prussia. M. Hasslacher has, in his notice, given valuable and detailed accounts of the influences and other matters connected with fire-damp explosions, which may be summarised briefly as follows, the paper itself being, however, deserving of close study.

From 1852 (when statistics were first employed) to 1881—say 30 years—the output increased from 4,899,771 tons to 43,889,410 tons. The number of workmen also increased from 36,029 in 1852 to 162,952 in 1881, and the fatal accidents in that period amounted to 8,483, or an annual average of 2·759 per 1,000 of workmen employed. The percentage of these accidents show (contrary to the received opinion) that fire-damp is not the most active agent in such disasters. Taking each hundred of such fatal accidents, the percentage may be thus summarised:—

	Per Cent.
Falls of stone or coal	38·4
Shafts and inclined planes	23·1
Fire-damp explosions	11·0
Choke-damp or other cause of suffocation	3·2
Sundry causes	24·3
	100·

The proportionate percentage of fatal accidents from fire-damp appears higher in other countries. England gives 23·1 per cent., France 22·34 per cent., Belgium 14·3 per cent., and so on; the tabulated numbers of tons and workmen to the accidents appearing strongly in favour of Prussia.

M. HASSLACHER then sub-divides his reports under the heads of fatal and non-fatal accidents, compared with production and detailing the number of victims in each case. The following account of serious accidents in Prussia from 1861 to 1881 will be perused with interest:—

Killed.	Injured	Date of Accident.	Situation.
81	10	Jan. 15, 1868	Westphalia.
35	3	Dec. 12, 1870	Do.
34	7	Oct. 20, 1864	Sarrebruck.
23	3	June 8, 1880	Westphalia.
17	16	Jan. 29, 1880	Wealden formation of North Germany.
17	5	June 24, 1881	Westphalia.

The number of fire-damp accidents is stated to have increased with the greater depth attained to. The conditions also appear to depend upon the nature of the superincumbent strata, the mode of working, and especially the number of seams simultaneously worked from the same shafts.

Outbursts of gas are comparatively rare, and continuous feeders from troubles or faults are much more serious. Coal dust is not quoted as a constant accompaniment of explosions, but severe accidents in damp workings are infrequent.

Out of 1,240 cases of killed and injured, the proportion per week day is thus summarised:—

Sunday	34
Monday	256
Tuesday	213
Wednesday	177
Thursday	209
Friday	187
Saturday	173
	1,249

The largest number occurring in March and December, and the smallest in April and May.

Tables are given of the causes of ignition of the fire-damp, showing that 58·3 per cent. is due to the use of naked lights, 10·3 per cent. to sudden movement of safety-lamps, and 12·9 per cent. to shot firing. D. P. M.

THE DIAMOND MINES OF KIMBERLEY AND DE BEER'S, CAPE OF GOOD HOPE.

Report presented to Parliament by T. P. WATSON, C.E., *and dated 26th June,* 1883; *pp.* 5–19. *Twelve folding Plates.*

The diamond-bearing ground at Kimberley has the form of a column standing erect, and extending to an unknown depth. It is about 9 acres in area (horizontal section), and somewhat irregular in shape, but approaches that of an ellipse with axes 500 feet and 700 feet respectively. The top of the column was composed of red sand, under this was a bed of yellow rock, and below these a bed of blue ground of unknown thickness, but which has been proved to a depth of 546 feet from the surface.

The rock surrounding the column is of the following character:—Yellow columnar basalt, varying in thickness from 30 feet on the south side of the mine to 60 feet on the north; black argillaceous shale, containing iron pyrites, and decomposing on exposure to the air, about 250 feet; hard igneous rock of unknown thickness.

Up to the present time the diamondiferous rock has been quarried by a number of small proprietors, each owning a claim about 30 feet square, but taxed jointly for the purpose of removing the baring. The mine has been lowered to a depth of 420 feet in its deepest part, and the present system of open working is no longer applicable, the sides falling in upon the workings.

Mr. Watson's principal recommendations are, that the proprietors should amalgamate; that the extent and nature of the hard rock encasing the diamondiferous ground should be proved. This being done, the proprietors will be in a position to decide whether to slope back the yellow basalt and argillaceous shale, at a cost of about £1,754,625, or about 7s. 6d. per cubic yard, the hard rock being found sufficiently solid to stand vertically (£1,548,358, or about 11s. 3d. per cubic yard of solid reef, has already been spent by the Mining Board in lowering the workings to their present position); or, the hard rock not being sufficiently strong, to stop the open working altogether and begin to mine.

De Beer's mine is not yet very far advanced, but the falling in of the reef upon the workings will have to be contended with before very long. J. H. M.

ANTHRACITE COAL REGIONS OF PENNSYLVANIA.

Reports of the American Inspectors of Mines, 1881 *and* 1882.

		1881.			1882.		
		Tons.	Workmen.	Kegs of Powder.	Tons.	Workmen.	Kegs of Powder.
Schuylkill district,	Pottsville ...	1,829,656	6,497	33,493	1,709,280	6,632	35,591
	Shenandoah ...	4,504,624	10,911	97,391	4,661,024	12,361	100,768
	Shamokin ...	4,432,601	11,865	84,578	4,588,799	12,973	93,514
Luyerne and carbon counties,	Middle district ...	7,021,508	16,808	152,511	7,059,358	17,883	149,276
	Eastern district ...	7,711,660	18,840	94,274	7.922,318	20,197	84,464
	Southern district..	5,037,948	11,386	88,917	5,360,497	12,298	91,880
		30,537,997	76,307	551,164	31,301,276	82,344	555,493

This is equal for the two years to 390 tons per workman employed, and to 2·23* tons per pound of gunpowder used. One keg is 25 lbs. There is one inspector for each of the above six districts.

Vol. I., 1881, pp. 70–77, gives an account of the extinction of the Kepley's run colliery fire, illustrated by ten plates and one folding plan; pp. 146–150, Scharar's new double fan, illustrated by one folding plate; pp. 227–233, the rules adopted by the coal operators and mine superintendents of the eastern district of the Wyoming and Lackawanna coal-fields, at the Mine Inspector's office, Scranton, Pennsylvania, December 24th, 1881.

Vol. II., pp. 108–120, remarks on underground fires (which are not uncommon in Pennsylvania), including Mr. Goldsworthy Gurney's method of extinguishing them in detail, and illustrated by one plate. J. H. M.

* The seams lying at high angles, there is a great deal of stone work.—Sub-Editor.

HAULAGE.

Rapport sur l'ouvrage presénté par ALFRED ÉVRARD, *intitulé: "Les Moyens de Transport, appliqués dans les mines, les usines et les travaux publics." Par* MM. LISBET, FRICHOT, ETC. *Bulletin de la Société Industrielle du Nord de la France*, 1883, *pp.* 36–41.

This book by M. Evrard is in two volumes of about 600 pages each, and is illustrated by an atlas containing 122 plates. It goes very fully into the various systems of haulage both above and below ground, and M. Evrard has been awarded a gold medal for the work, a copy of which is in the library of the North of England Institute.

J. H. M.

THE SEA IN THE INTERIOR OF AFRICA.

Note sur la mer intérieure. Par M. A. HAUET. *Mémoires et Compte Rendu des travaux de la Société des Ingénieurs Civils, Ser.* 4, 1883, *pp.* 110–119, *one folding Plate.*

In Africa, a little to the south of Biskra, there are three depressions, viz.:—The Chott Mel R'ir, 25 metres below the level of the sea; the Chott Rharsa, 20 metres below the level of the sea; and the Chott el Djeriel, also below sea level. It is proposed to make a canal, 200 kilometres in length, from Gabes to these Chotts, to excavate 600,000,000 of cubic metres of earth, and to spread over an area of 8,000 square kilometres (3,080 square miles) 200 milliards of cubic metres of water from the Mediterranean. The cost will be a milliard of francs (£40,000,000). It is estimated that the excess of evaporation above the drainage of the basin will be six milliards of cubic metres a year, and to supply this loss the canal must be 30 metres broad at the bottom, 72 at the top, and 14 deep, with a fall of 35 millimetres per kilometre. In passing through hard rock the section will be less, the fall more.

Two French commissions have examined into this project; one, official, has reported against it; the other, a private commission under the patronage of M. de Lesseps, is favourably disposed towards it.

M. Hauet is strongly opposed to the scheme. He thinks that, even could it be made a commercial success, the new nation to be created on its borders would be composed for the most part of Italians and Spaniards, that is to say, a nation which would soon separate itself from the mother-country, and France would have another rival upon the Mediterranean.

J. H. M.

REFORM OF THE PERMANENT WAY.

Réforme de la voie permanente des chemins de fer. Par M. CHARLES BERGERON. *Mémoires et Compte Rendu des travaux de la Société des Ingenieurs Civils, Ser.* 4, 1883, *pp.* 261–285; *ten Figs. in text.*

The author describes the present system of forming the permanent way of a railway and points out the impossibility of ballasting so that the bearing of each sleeper may be the same. This he believes to be the cause of trains getting off the line when running at high velocities, and to be the cause of the shocks to which the rolling stock is subjected. He thinks it impossible to remedy these defects with the present system of permanent way, and proposes that wooden sleepers and ballast should be done away with altogether and the following arrangement adopted.

The roadway having been formed in the usual manner—excepting that it need only now be 4 metres wide for a single way instead of 6—he cuts a pair of longitudinal trenches, 0·50 metre wide × 0·50 metre deep and 1·50 metre apart from centre to centre. These he fills with sand rammed in hard. The sleepers are combined chairs

and sleepers made of iron, similar to the caisson chairs of Mr. Livesey, of Glasgow, ⊓ shaped, 0·60 metre × 0·30 metre and 0·20 metre deep, set longitudinally and driven down into the sand. To enable them to penetrate the edges are sharpened. Chairs are attached to these, and the rail rests upon them (wood, or some other elastic substance being interposed) having a bearing for the whole of their length, so that much lighter rails can be used than in the ordinary system. The sleepers are spaced 1 metre apart from centre to centre, so that there is only 0·40 metres interval between each. The author believes that by this method a very firm, but elastic permanent way will be obtained needing very few repairs, and upon which velocities of sixty miles an hour and upwards may be maintained without danger.

1.—*Comparative cost of M. Bergeron's system:—*

	Francs per 9 Metres.
Cutting the trenches	9·00
Filling trenches with sand at 3 francs per m³ and labour	22·50
Iron sleepers, each weighing 45 kilogrammes, at 100 francs per tonne	81·00
Tie rods, each 10 kilogrammes, at 160 francs...	28·80
Keys to fasten tie rods to the sleepers, at 0·20 francs each	14·40
Steel rails, 25 kilogrammes per metre, at 160 francs per tonne ...	72·00
Laying the way, at 2 francs per metre	18·00
Keys, at ·30 francs each	5·40
	251·10

Equal to 27·90 francs per metre, or £1 0s. 6d. per yard.

2.—*Comparative cost of present system in England:—*

Ballast, 2 m³ per metre, at 3 francs per m³	54·00
Twelve larch sleepers, at 5 francs each	60·00
Twenty-four chairs, 20 kilogrammes each, at 100 francs per tonne	48·00
72 spikes, at ·30 francs each	21·60
18 metres of double-headed steel rails, 40 kilogrammes per metre, at 160 francs per tonne	115·20
18 keys	5·40
Laying way, at 1 franc per metre	9·00
	313·20

Equal to 34·80 francs per metre, or £1 5s. 4d. per yard.

3.—*Comparative cost of present system in France:—*

Ballast, 18 m³ of broken stones, at 3·5...	63·00
12 oak sleepers, at 6 francs each	72·00
Rails, Vignole's price and weight, as above	115·20
48 spikes, at ·30 francs each	14·40
Laying the way	9·00
	273·60

Equal to 30·30 francs per metre, or £1 2s. per yard.

There is therefore a considerable saving in the cost of establishment. But in addition to this the author claims for his system:—1st. A saving due to a reduction in the width of the roadway from 6 metres to 4 metres. 2nd. Saving due to the suppression of wooden sleepers, which require constant renewing. 3rd. Saving in labour of re-ballasting. J. H. M.

HARDENING STONE.

Note sur un procédé de durcissement des pierres calcaires tendres au moyen des fluosilicates a base d'oxydes insolubles. Par MM. FAURE ET L. KESSLER. *Mémoires et Compte Rendu des Travaux de la Société des Ingénieurs Civils, Ser.* 4, 1883, *pp.* 120–122.

The authors point out the defects of the old system of hardening tender stones by impregnating them with alkaline silicates, such as those of potash and soda. They propose instead soluble silicates of metals of which the oxides or the carbonates are insoluble, the fluosilicate of magnesia, aluminium, zinc, or lead. The advantages claimed are:—

1.—To make the most tender limestones very hard.

2.—To make them impermeable.

3.—To polish them, closing all the superficial cavities.

Their method has already been tried at several places, amongst others on the new Hotel des Postes. J. H. M.

COATING FOR TELEGRAPH WIRES.

Nouveau mode d'isolement des fils métalliques employés dans la Télégraphie et la Téléphonie, par M. C. WIDEMAN, *Comptes Rendus, Vol. XCVII.*, 1883, *pp.* 852–853.

M. Wideman finds that a telegraph wire (copper, brass, or iron) coated with peroxide of lead or iron is as completely isolated as a wire covered in the ordinary way with resin or gutta-percha, and the cost is much less.

The method of preparation is as follows:—10 gr. of litharge are dissolved in one litre of water, to which 200 gr. of caustic potash are added, and the mixture boiled for half-an-hour. It is then allowed to stand, decanted, and the bath is ready. The wire to be coated is attached to the positive terminal, and a platinum anode to the negative terminal, and both are put into the bath. Metallic lead is precipitated upon the negative pole, and peroxide of lead upon the wire, passing successively through all the colours of the spectrum; but the coating is not perfect until the last tint, a brownish black, is reached. J. H. M.

HOT WATER LOCOMOTIVES.

Rapport sur les locomotives a eau chaude du système Francq et Lamm, par MM. HIRSCH, FLOURENS *et* DU BOUSQUET. *Bulletin de la Société Industrielle du Nord*, 1883, *pp.* 43–46.

These engines have been designed to take the place of horses upon tramways, and are now at work at Lille, Marly-le-Roi, and other towns. Each consists of a receiver, pressed to sixteen atmospheres, into which from 1,800 to 2,000 kilog. of water, at a temperature of 203° C., have been forced. This water contains sufficient heat to convert a portion of itself into steam, at pressures of three, four, or five atmospheres. Given, therefore, a receiver large enough, and containing water hot enough, sufficient heat will be provided to generate steam for the cylinders which are attached to the receiver, and to drive the locomotive the distance required. By means of an expansion valve the admission of the steam into the cylinders is so regulated that its pressure in the cylinders may be the same throughout the whole of the run. The exhaust steam is passed through a cold air condenser. Fixed boilers, placed at convenient stations, re-charge the locomotives with steam. J. H. M.

OPENING OF THE MINING EXHIBITION (EXPOSICION DE MINERIA) AT MADRID.

La Apertura de la Exposicion. Por ROMAN ORIOL. *Revista Minera y Metalurgica, Ser. C., Vol.* 1, 1883, *pp.* 295, 296.

This Exhibition, which was opened on the 30th of May, 1883, by the Kings of Spain and Portugal, marks a memorable epoch in the history of the recent development of Spanish industry. The scheme was originally started by the press, but owing to the deficiency of private enterprise in Spain, it could not have been carried out if it had not been warmly taken up by the Spanish Government, which issued a decree, August 4th, 1882, declaring the Exhibition deserving of official support. The necessary arrangements were entrusted to Don Luis de la Escosura, the head of the National Corporation of Mines, and the organizing committee which worked under him received ready and valuable assistance from the engineers of that body as well as from those of the provinces.

The area of the Exhibition was covered by installations from various firms and private individuals, and an international character was given to it by the pavilions of Sweden, England, Germany, Belgium, and Portugal. In spite of some omissions, an approximate idea could be formed, from the many specimens and objects exhibited, of the mineral and metallurgical industries of Spain, of her potteries, glass works, and mineral waters. The Minister of Industry, Don German Gamazo, dwelt in his opening speech on the importance now attained by these industries in Spain, rich as that country is in the elementary materials of manufacture—iron, lead, copper, coal —as well as on the progress made in metallurgy and ceramics. He spoke also of the advantages derived by agriculture from the improvement in these arts, in the shape of the tools and machines provided by them. J. H. M.

THE LEAD WORKS OF PUERTOLLANO.

La Fabrica de Puertollano en la Exposicion de Minería. Revista Minera y Metalurgica, Ser. C., Vol. 1, 1883, *pp.* 329, 330.

In the department of the Mining Exhibition occupied by the Arrayanes Mine, Don José Genaro Villanova gives an explanation of the plans he exhibits of the lead works he has established at Puertollano, projected, constructed, and directed by Don Manuel Sanchez y Massia, of the National Corporation of Mines. Besides the general plan, there are others of the various buildings, furnaces, and other details, giving a very accurate idea of the whole. Specimens are also shown of the materials for the constructions—the combustibles, minerals, and products in different stages of the process, as well as the implements used in the work of each furnace, and some waggons of iron of very simple construction, two of which were devised by Señor Sanchez y Massia, and made in the small forge of these works under his directions. The whole is accompanied by a brief and clearly-expressed memoir describing the works.

Attention should be directed to the methodical arrangement of the works; to the graduated fire-bars, by means of which the small coals are burnt, and to the use of gasogenes in the calcinating furnace. The model of wind furnaces, on the scale of one-tenth, constructed also in the Puertollano forge, is worthy of note.

Señor Sanchez y Massia had only proposed to make some modifications on the Piltz furnace; but he has effected more than this. His furnace is anterior to that of Karst, which it resembles, but with some points of superiority, such as the almost hermetic closing of the mouth, and the reservoirs of water for cooling the lower part of the furnace. J. H. M.

HISTORICAL RESUMÉ OF THE CHANNEL TUNNEL AND OF THE TRANSPORT OF POWER.

Résumé historique des études Géologiques et des Travaux d'excavation entrepris en France et en Angleterre en vue de l'execution d'un chemin de fer sous la manche. Renseignements et détails officiels sur les premières études pour la perforation mécanique et l'aération des longs tunnels par l'air comprimé.

Examen des procédés les plus économiques pour le transport des grandes forces motrices. Par M. DANIEL COLLADON. *Mémoires et Compte Rendu des Travaux de la Société des Ingénieurs Civils,* 1883, *pp.* 74–109. *One Figure.*

The author gives an account of the Channel Tunnel works from the formation of the first company, that of Sir John Hawkshaw, in 1865, down to the present time when the drift on the English side is standing at a distance of about 2,000 yards from the coast and on the French side is still being driven forward and has already reached about the same distance.

He also gives a short history of the transport of power by compressed air, beginning with some experiments made by himself in 1849, with a view to the piercing of Mont Cenis. J. H. M.

HISTORY OF MINING IN SPAIN AND PORTUGAL.

Consideraciones sobre la Minería de la Peninsula. Por FERNANDO BERNALDEZ. *Revista Minera y Metalurgica, Ser. C.,* 1883, *pp.* 263–266 *and* 279–281.

Señor Fernando Bernaldez has contributed to the "Revista Minera" two interesting articles of some length on this subject, from which space will allow us to give only a few chronological data. The Asturias, Galicia, Leon, Estremadura, Huelva, and Murcia contain many remains of the mines of antiquity. The Phœnicians first appear to have explored the metalliferous riches of the Peninsula, but, as well as the Carthagenians who followed them, confined their operations to the vicinity of the seaboard. The Romans carried their discoveries far into the interior. Large quantities of gold were obtained in the Asturias, Galicia, Leon, and parts of Lusitania; the principal regions of it were the alluvial plains of the Vierzo and the districts of Valdehorras and Quiroga. Auriferous quartz was also found in the districts of Salas, Pola de Allande, and De Belmonte, in the Asturias; and in the extensive zone situated to the south of the Tagus, in Estremadura, where many pits and other remains are found. Silver was obtained from the argentiferous lead of the provinces of Badajos, Cordova, Cuidad Real, Almeria, and Cartagena, and from a mixture of grey copper with lead. The sulphurs, oxides, and carbonates of copper produced abundance of that metal from the rich veins of Estremadura and Huelva, where the vast exhausted mines and ancient works attest the activity of those early workers. Very large quantities of lead must also have been supplied from the deep and extensive, but now exhausted, mines of Murcia. Galicia and Zamora supplied excellent tin, and we learn from Theophrastus and Pliny that sulphurate of mercury was found in the Sisaponeme district—Almaden. Lastly, we must mention the steel and iron, for which Zaragoza, Calatayud, and, above all, Galicia was renowned.

With the irruption of the northern nations these industrial works were abandoned, nor were they much resumed during the long wars of the Moorish dominion. In 1168, however, we find King Alfonzo VIII. making a grant of the moiety of Chillon and Almaden to the friars of Calatrava and the Count Don Nuño for mining purposes, and many other grants of the same nature are found among the Spanish records. During

the thirteen years from 1512 to 1525, when these mines were in the hands of the State, they produced as much as 500 quintals of quicksilver. In 1555, when Charles V. was on the throne, the silver mines of Guadalcanal were discovered, and between that year and 1576 they produced 400,000 *marcos* of silver (a *marco* is equal to 3,552 grains English). The neglected mines of Rio Tinto, now worked by an English company, were revived in the beginning of the eighteenth century.

During the political disturbances of the present century legislation on the subject of the mining industries was neglected, but laws for their better regulation have been passed in recent years. J. H. M.

THE NEW IRON WORKS OF TRUBIA.

La Nueva Fábrica de Trubia. Revista Minera y Metalurgica, Vol. 1, 1883, *p.* 163.

This article describes the newly-founded ironworks in the plain of Trubia, at the commencement of the North-Western Railway, belonging to the Mining and Smelting Company of Santander and Quiros, the object of which is the conversion into forged and laminated iron of the ore obtained in Quiros, where the company possesses large tracts containing coal and iron ore, with everything necessary for working the mines, and where they are now erecting a tall furnace according to the most recent improvements. The first iron produced, in February, 1882, was used for the rails of the company's trams connecting the different centres of iron and coal with the smelting house. In May they began to work the iron for commercial purposes, which obtained a high reputation from the first moment of its appearance in the market, and which was to be represented in the Exhibition in a special pavilion. From February, 1882, to January 1st, 1883, the products obtained from the works were :—

	Tons.
Iron for the company's tramways	900
Rails for company's mines	250
Rails sold	3,250
Total	4,400
Puddled iron bars	6,200

319 work-people are employed, including women and children. J. H. M.

SOUTH AFRICAN DIAMOND DEPOSITS.

Om Diamantfälten i Syd-Afrika. By A. Sjögren. *Geologiska Föreningens i Stockholm Förhandlingar, Vol. VI., pp.* 10–27, *with one Plate.*

Comprises a general description of the mode of occurrence of diamonds in South Africa and a discussion of their origin. At Kimberley the diamonds occur in a mass of "tuff," or loose-textured volcanic matter, filling vertical-sided natural pits (probably ancient necks of igneous rock) of irregular shape. The walls of the diamond "pits" are formed (in ascending order) of a volcanic diabase, blue shale or schists, and an olivine basalt. At De Beer's mine the rocks are arranged much in the same manner, except that no diabase has, so far, been met with below the schists, and that narrow irregular dykes or veins of basalt occur within the "neck" itself, intruded through the diamond tuff-rock. Eight theories accounting for the presence of the diamonds are mentioned. G. A. L.

IRON ORE OF MEXICO.

Martite of the Cerro de Mercado, or Iron Mountain, of Durango, Mexico, and certain Iron Ores of Sinaloa. By B. SILLIMAN. *American Journal of Science, Ser.* 3, *Vol. XXIV., pp.* 375–379. *One Woodcut in text.*

The Cerro de Mercado, a mountain 600 feet high (above the plain from which it rises), a mile long and a third of a mile broad, is not, as has been often said, a solid mass of iron ore. "The surface of the hill, indeed, everywhere exposes masses of ore, which appear to be derived from one or more immense beds, or veins, of specular iron standing nearly vertical, the fragments of which form a talus on the slopes of the mountain, and conceal completely the enclosing walls of rock." The latter is a purple porphyry. An analysis of an average sample of the ore shows 2·071 of magnetic oxide of iron, 77·571 of ferric oxide, and 3·041 of phosphoric acid. This enormous mass of valuable iron ore is now, by the near approach of the railway system of Mexico, likely to become of commercial importance. The author quotes a Report on this "iron mountain" by Mr. Birkinbine, of Philadelphia, issued in 1882. A view of the Durango Hill is given.

Analyses of iron ore from Tepuche, on the Rio de Humaya, ten miles west of Culiacan; Bescuino, twenty miles east of the latter place; and Cosolu, are given, showing a yield of 65·08, 66·75, and 67·25 per cent. of metallic iron respectively.

G. A. L.

THE LIGNITE BASIN OF FUVEAU (SOUTH OF FRANCE).

Étude sur le bassin de Fuveau et sur un grand travail a y exécuter. By — VILLOT. *Annales des Mines, Ser.* 8, *Vol. IV.*, 1884, *pp.* 5–66. *Five folding Plates.*

The seams of lignite which have for many years been worked in the valley of the Arc, near Marseilles, and which constitute the Fuveau Basin, were formerly supposed to be of Miocene age. They are now known to belong to the Dordonian and Garumnian series, or, in other words, to the uppermost Cretaceous and lowest Eocene deposits of the region. This basin is of considerable commercial importance, the output of lignite having increased regularly year by year from 38,600 tons in 1840 to 457,000 tons in 1882. The latter figures show that this field contributes at the present time more than 2 per cent. of the entire coal production of France. The seams still unworked are of great extent, good quality, and sufficient thickness, and their working is not likely to be seriously affected by high dips or faults. Notwithstanding all these natural advantages, to which close proximity to a great port such as Marseilles must be added, the future of the field depends now upon the possibility of getting rid of the water which unfortunately occurs in the workings in formidable and yearly increasing quantities.

The object of this paper is to explain fully a scheme which is about to be adopted in order to form an outlet to the sea for the water flooding the pits. This scheme, which depends too much upon local details to be usefully abstracted, is founded upon accurate observations and mapping of the lie of the beds, their permeable character, and more particularly the dislocations by which they are affected. Among the latter certain funnel-shaped areas of disturbance, locally known as *moulières*, are of special interest.

G. A. L.

MINERALS OF NEW ZEALAND.

(1) *Notes on the Mineralogy of New Zealand.* *By* S. Herbert Cox. *Transactions of the New Zealand Institute, Vol. XV.*, 1883, *pp.* 361–409.

This is the continuation of a memoir which first appeared in the preceding volume of the Transactions of the New Zealand Institute. The principal useful minerals enumerated are:—*Graphite*, from three localities. *Coal*, viz., the lignites of recent Tertiary age; the brown coals of the Cretaceo-Tertiary formation, which are the most widely distributed in the colony; the pitch coals overlying the bituminous coal series of the west coast of South Island; glance coals of the Malvern Hills coal-field; the semi-bituminous coals of the Bay of Island, where the output of one colliery (Kawakawa) was 50,277 tons in 1882, or one-seventh of the total quantity raised in New Zealand during that year; the bituminous coals, confined to the west coast of South Island; bituminous peat of Chatham Islands; bituminous shale or torbanite from Awatere, near Mongonui, Auckland; and other carbonaceous minerals, elaterite and petroleum from several localities. *Sulphur*, deposited by geyserian springs on White Island and on other islands in the Bay of Plenty. *Marble*, fine deposits on the west coast of Otago and elsewhere. *Limestone*, very widely distributed and of various kinds. *Gypsum*, associated with the sulphur deposits, but apparently not in large workable quantities. A very full series of analyses of the varieties of coal from many localities and also of 49 mineral springs accompanies the description.

(2) *Handbook of New Zealand.* *By* Dr. James Hector, F.R.S. *3rd Edition*, 1883 *Wellington*, 147 *pp. with Maps and Plates.*

Much the same information is to be found in this guide as in Mr. Cox's "Notes," *plus* an account of the metalliferous ores of New Zealand. These are described under the following heads:—

Gold and Silver.—Quartz-mining, chiefly in the Coromandel and Thames districts, 30 miles apart. Some of the quartz reefs have yielded as much as 600 ounces of gold to the ton very uniformly for considerable distances; but these are, of course, exceptional. Alluvial mining, chiefly in the South Island, in the districts of Otago, Westland, and Nelson, in which mining operations are carried on over an area of about 20,000 square miles. The total quantity of gold entered for exportation from New Zealand up to the end of 1881 was 9,822,755 ounces (= £38,461,423), of silver 377,471 ounces (= £99,469).

Iron Ores.—These occur plentifully, but none are worked except the black iron sands which occur plentifully on the coasts.

Chrome Ore occurs in thick veins, and has been largely exported from Nelson.

Copper Ore occurs at many points, but does not appear to be largely worked.

Lead, Zinc, Antimony, and Manganese Ores are also present in considerable quantities in many localities, but are likewise not much worked at present.

An excellent geological map of the Islands accompanies this handbook.

(3) *Report on Control and Inspection of Mines.* *New Zealand*, 1883, *folio*, 28 *pp.* *Wellington*, 1883.

Much information respecting the seams of coal and lignite worked in the colony, besides statistics connected with the management of the mines (both coal and quartz) will also be found in this Annual Report of the Inspectors to the Minister of Mines.

G. A. L.

PLATINUM IN A LODE.

On the Occurrence of Platinum in Quartz Lodes at the Thames Gold-fields, New Zealand. By J. A. POND. *Transactions of the New Zealand Institute, Vol. XV.*, 1883, *pp.* 419, 420.

Notes the occurrence of platinum in rounded grains and in perfect octahedral crystals in a quartz vein impregnated with gold-bearing iron pyrites, met with in deepening the shaft of the Queen of Beauty Gold-mining Company from the 540 feet to the 600 feet level. The interest of this note lies in the fact of the extreme rarity of platinum in place, *i.e.*, in its native rock or vein. G. A. L.

ANALYSES OF COALS AND LIGNITES.

Bulletin des Travaux de Chimie exécutés en 1881 *par les Ingénieurs des Mines dans les laboratoires départementaux. Annales des Mines, Ser.* 8, *Vol. IV.*, 1884, *pp.* 133–196.

The following are selected from these Reports:—

	Fixed Carbon.	Volatile Matter	Ash.
1.—Anthracite of Rhætic (?) age from Ujbanya, near Orsova, in the Banat	74·74	13·86	10·10
2.—Coal from the St. Victor Seam, at La Madeleine Colliery, Department of Var ...	41·70	47·50	10·80
3.—Lignite of Banc-Rouge (South of France)...	36·25	44·75	19·00
4.—Anthracite of Prades (South of France) ...	66·71	11·54	21·75
5.—Gas coal of St. Etienne	60·71	32·75	6·54
6.—Coals of St. Laurs, Department of Deux-Sèvres, mean of nine analyses	71·77	20·26	7·85
7.—Lignite from near Dellys, in Algeria (Algiers District)	48·16	14·42	36·14
8.—Lignite from Fedj-Mzala, Algeria (Constantine)	41·40	56·60	5·00

G. A. L.

COPPER IN TEXAS.

Copper-bearing Region in Northern Texas and the Indian Territory. By J. H. FURMAN. *Transactions of the New York Academy of Sciences for* 1881–1882 (1882), *p.* 16.

An account of the occurrence of copper ores in a narrow belt not more than 50 yards in breadth, but several miles in length, along the southern boundary of Haskell County, in Knox and Hardeman Counties, and beyond Texas in the Indian Territory. This copper zone consists of Triassic shale underlying a well-marked gypseous sandstone. The ore is sometimes native copper in nuggets, sometimes fossil wood impregnated with copper; some green carbonate of copper (malachite) also occurs as a secondary product. In the discussion upon this paper Professor Newberry described similar copper deposits in New Mexico and Utah. G. A. L.

ANALYSES OF COMBUSTIBLE MINERALS.

Sur la composition des substances minérales combustibles. *By* — BOUSSINGAULT. *Annales de Chimie et de Physique, Sér.* 5, *Vol. XXIX.*, 1883, *pp.* 363–392.

The general results of the analyses given are thus tabulated:—

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.
Liquid bitumen of Bechelbronn	87·50	11·10	0·30	1·10
Bitumen of Bocanémé	88·52	11·36	0·00	0·12
Bitumen of Schwabwiler	85·38	12·33	2·17	0·12
Bitumen of Ambalema, Magdalena ...	88·31	9·64	1·68	0·37
Liquid bitumen, Hatten (Alsace) ...	87·40	12·60	0·00	0·00
Bitumen of Orinoco	77·93	7·94	13·87	0·26
Black naphtha of Balakhany	85·42	6·66	7·76	0·16
Bitumen of Bastennes	85·74	9·58	2·88	1·80
Bitumen of Pont-du-Château	77·52	9·58	10·53	2·37
Bitumen of the Abruzzi, Naples	81·83	8·28	8·83	1·06
Bitumen of the Chinese fire-wells (filtered)	86·82	13·16	0·00	0·02
Do. do. (squeezed out)	82·85	13·09	4·06	0·00
Bitumen of Judæa	77·84	8·92	11·53	1·71
Asphalt of Coxitambo, Peru	87·75	9·68	2·58	0·00
Asphalt of Oran, Algeria	73·47	10·48	15·49	0·56
Asphalt of Egypt	85·29	8·24	6·22	0·25
Mineral wax of Bakin, Russia	84·33	13·71	1·96	0·00
Fossil resin of Bucaramanga	82·70	108·0	6·50	0·00
Fossil resin of Santa-Rosa, Antioquia ...	77·80	9·60	12·57	0·03
Fossil resin of El Retiro, Antioquia ...	71·89	6·51	21·57	0·03
Copaline of Highgate	85·68	11·47	2·85	0·06
Copaline of India	85·73	11·50	2·77	0·00
Guayaquilite resin, Ecuador	77·66	8·20	14·80	0·00
Retinasphalt of Bovey-Tracy	74·12	8·18	17·51	0·19
Elaterite of Australia	72·15	10·30	16·84	0·71
Elaterite of Wallachia	69·70	10·19	19·40	0·71
Jonite of California	67·55	7·13	25·05	0·27
Torbanite of Scotland	82·30	10·50	5·00	2·20
Dysodil of Roth	69·01	10·04	19·25	1·70
Dysodil of Sicily	57·73	9·35	31·91	1·01
Lignite of Antioquia	66·81	4·84	27·27	0·98
Lignite of Chile	79·24	5·50	13·69	1·57
Bituminous lignite of Elboyen	77·04	7·81	12·65	1·86
Jet of Spain	81·98	5·81	11·53	0·68
Fibrous coal of Antioquia	87·05	5·00	6·56	1·39
Coal of Canoas, Bogota	80·96	5·13	12·50	1·41
Coal of Montrambert	82·33	3·52	12·52	1·65
Cannel coal of Montrambert	86·67	4·56	7·98	0·79
Fossil charcoal of Blanzy	87·81	3·88	7·67	0·64
Fossil charcoal of Montrambert	86·67	4·56	7·98	0·79
Anthracite of La Mure (Isère)	95·26	2·51	1·56	0·67
Spheroidal anthracite	91·51	3·87	3·36	1·26
Anthracite of Borneo	93·66	2·94	2·88	0·52
Anthracite of Chile	92·25	2·27	4·94	0·56
Anthracite of Pembrokeshire	95·34	2·42	1·35	0·89
Anthracite of Muso	94·83	1·27	3·16	0·74
Adamantine anthracite	97·60	0·70	1·70	0·00
Graphite of Korsöh	97·87	0·37	1·70	0·06

G. A. L.

KAOLIN IN SWEDEN.

(1) *Kaolinfyndigheten vid Hultebo i Skinnskattebergs socken och Örebro län.* *By* B. SANTESSON. *Geologiska Föreningens i Stockholm Förhandlingar, Vol. VI., pp.* 325–330, *with one Plate.*

An account of a deposit of china clay discovered in Vestmanland, at Hultebo, to the north-west of Skinnskatteberg. The deposit occurs beneath a considerable thickness of drift sand and gravel, and is due to the decomposition of the upper portion of a broad zone of *eurite* (felsite), which runs in a north-east and south-west direction between two large areas of gneiss-granite on the one hand and micaschist on the other. The kaolin is white, yellowish-green, grey, and red, the white containing the most silica and the red the least. Full analyses of the various kinds are given and compared with those of the well-known china-clays of Aue, Halle, Limoges, and Meissen, with which they have much in common.

(2) *Om förekomsten af kaolin och kaolinblandad lera i norra Skåne.* *By* AXEL LINDSTRÖM. *Geologiska Föreningens i Stockholm Förhandlingar, Vol. VI., pp.* 416–425, *with one Plate.*

Describes the occurrence of china-clay at twenty-four localities in Northern Scania. Analyses of the clay from Bosjökloster and Mjölkalånga are given and compared with the above-mentioned kaolin from Hultebo. The Scania clays are in both cases more siliceous than the latter. These newly-discovered Swedish deposits are of workable extent and promise to become valuable in time. G. A. L.

RECENT VEIN-FILLING.

On Mineral Vein Formation now in progress at Steamboat Springs, compared with the same at Sulphur Bank. *By* PROFESSOR JOSEPH LE CONTE. *American Journal of Science, Ser.* 3, *Vol. XXV.*, 1883, *pp.* 424–428, *two Figures in text.*

The Steamboat Springs are in Washoe County, Nevada, on the railway to Carson and Virginia City. They occur at intervals along lines of fissures in the geyserian deposit of the springs themselves. The latter are partly filled and are now filling with quartz veinstone of ribboned structure, and containing metallic sulphides. After comparing the phenomena exhibited by these modern veins and the well-known ones at Sulphur Bank, the author thus sums up the facts to be inferred from them :—"1.—In true geysers the waters being pure alkaline carbonates deposit only silica. 2.—At Steamboat Springs there are some alkaline sulphides, but not enough to prevent a crust of deposited silica. 3.—At the California Geysers—so-called—solfataric action is conspicuous, and therefore no crust is formed, but only earthy residue of acid decomposition of surface rocks. Here we have also metallic sulphides deposited, but these are of little value. 4.—At the cinnabar mines, near Steamboat Springs, we have solfataric waters depositing cinnabar and other metallic sulphides in considerable quantity, but whether in profitable quantity cannot be known certainly unless deeper explorations be undertaken. Finally, at Sulphur Bank, the deposit of the metallic sulphides is abundant, and the formation of metalliferous veins is illustrated in the most perfect manner on account of the deep explorations undertaken at this place." . . . "It would seem that igneous *action* supplies a necessary *condition* (heat) for the formation, rather than that igneous *rocks* supply the *materials* of metalliferous veins." (p. 428.)

This paper is a continuation of one in Vol. XXIV. of the *Journal*, page 23, on the Sulphur Bank mineral deposits. G. A. L.

ORIGIN OF MINERAL VEINS.

On the Genesis of Metalliferous Veins. By PROFESSOR JOSEPH LE CONTE. *American Journal of Science, Ser.* 3, *Vol. XXVI.*, 1883, *pp.* 1–19.

The author regards the view that metalliferous veins have been deposited from solutions as thoroughly established, even in the case of cinnabar. In this paper he discusses the conditions under which deposit takes place, and what in addition to water have been the solvents. Cooling and relief of pressure have been the chief cause of deposit, but to this must be added (*a*) the agency of organic matter circulating in the same solution with metallic sulphates in reducing them and depositing them as metallic sulphides; (*b*) the neutralization by the acids of organic decomposition of alkaline, carbonate, and sulphide waters holding silica and metallic sulphides in solution, and the consequent deposition of the latter; (*c*) the meeting in the same fissure of waters charged with different materials resulting in re-action and deposition. The above, the author believes, "is an outline of a true theory of the genesis of metalliferous veins." (p. 5.)

Dr. F. Sandberger's views of vein-formation are then stated and criticised, and the author's principles are next applied to the explanation of the ordinary phenomena of mineral veins taken in the following order:—1.—Association with metamorphism. 2.—Absence of surface effects of solfataric action. 3.—Variation in vein contents. 4.—Variation of richness with depth. 5.—Origin of the alkaline and metallic sulphides. 6.—Heat not always necessary. 7.—Occurrence of gold (originally in solution as a sulphide, and deposited with other metallic sulphides, but being extremely unstable as a sulphide gave up its sulphur to the alkali at the moment of its deposition). 8.—Different kinds of veins, viz.:—fissure veins, incipient fissures, irregular veins, substitution veins, contact veins, and irregular ore deposits. G. A. L.

MAGNETIC BRICKS.

Experiments by PROFESSOR DR. KOBALD. *Vereins-Mittheilungen, Beilage zur oesterreichischen Zeitschrift für Berg- und Hüttenwesen*, 1883, *p.* 48.

At a distance of about two yards from a very sensitive magnetometer was placed a transparent measuring scale, set perpendicular to the magnetic meridian, and various objects being placed at distances of about one yard from the magnetic bar of the instrument, its movement, as read from the scale, was as follows:—

	Inches.
1.—A common wall brick	2
2.—Wall bricks made at Lesben and	
(*a*) Air dried, almost	—
(*b*) Half burnt	8
(*c*) Thoroughly burnt	18
3.—Brick from boundary wall of the Halle salt mine ...	$21\frac{1}{2}$
4.—Burnt shale from a brickfield at the Tollinggrab colliery	2
5.—Serpentine stone from Kraubath	$\frac{3}{4}$
6.—Trachyte (2 pieces)	$\frac{3}{8}$ to $1\frac{3}{16}$
7.—Chrome ore from Kraubath	$2\frac{3}{8}$
8.—Clean sparry iron ore	—
9.—Calcined „ „	$19\frac{3}{4}$
10.—Iron screw, at a distance of 4 inches, of considerable influence, but at a distance of 2 feet 7 inches ...	—

A. R. L.

ECONOMY OF FUEL IN IRON MANUFACTURE.

Studien über Brennstoff-Ersparung bei einigen Hüttenprocessen. PROFESSOR KUPELWIESER. *Vereins Mittheilungen, Beilage zur oesterreichischen Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 27–29.

The Givors Ironworks possesses three blast-furnaces, of which two are usually at work, and two Bessemer converters.

The two boilers, in which steam is generated for the blast, stand one above another, and are heated by gas from the blast furnaces instead of by the usual methods of separate firing. The gases are first led into a separate chamber and mixed with previously heated air, and thence made to pass under the upper boiler and right round the lower one, reaching the chimney at a temperature of about 530° F.

The saving of fuel by this means amounts to from 20 to 30 tons per 100 tons of Bessemer ingots produced.

In cases where it is possible to convert the ingots at once into finished iron a further saving in heat, and therefore in fuel, can be effected by working them before they have had time to cool, and, considering these two savings, what may be called the combination system of working will compare with the usual system as follows:—

TO PRODUCE 100 TONS OF RAILS.

	Usual System. Tons.	Combination System. Tons.
Ingots	120 ...	116
Raw iron	133·2 ...	128·8
Iron ore	252 ...	245

FUEL.

	Tons.	Tons.
(*a*) Coke for production of raw iron ...	133·2 ...	128·8
(*b*) „ Bessemer process	6 ...	5·8
„ „ as boiler firing	30 ...	—
(*c*) Coal for rolling (exclusive of that for motive power)	30 ...	—

TOTAL AMOUNT OF FUEL REQUIRED.

	Tons.	Tons.
Coke	139·2 ...	134·6
Coal	60 ...	—

A. R. L.

WATER GAS.

Erzeugung und Verwendung von Wassergas als Brenn- und Beleuchtungs materiale. HOFRATH VON TUNNER. *Vereins-Mittheilungen, Beilage zur oesterreichischen Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 48–49.

A comparison between common gas and water gas made by Strong's Gas Generator shows that 1 lb. of clean coal will, in the first case, produce 88 cubic feet of heating gas with 948 cubic feet of illuminating gas of 3,416° F., or 22,144 units of heat. In the case of water gas 1 lb. of coal will produce 68 cubic feet of heating gas with 1,137 cubic feet of illuminating gas of 5,135° F., or 41,667 units of heat, giving thus nearly twice as many units of heat and a temperature about one-third higher. This apparent gain is, however, balanced by the loss of the fuel expended in raising the steam required in the water gas process. A. R. L.

BLASTING WITH DISTRIBUTED CHARGES.

Sprengungen mit vertheilten Ladungen. HUGO MÜNCH. *Vereins-Mittheilungen, Beilage zur oesterreichischen Zeitschrift für Berg- und Hüttenwesen,* 1883, *pp.* 52–53.

During some quarrying operations at Trifail a mass of 11,137 cubic yards of rock was blasted down with 170·775 lbs. of dynamite in eight charges, which were fired simultaneously by electricity. The cost for material and wages amounted to £97, or 2·09d. per cubic yard. Herr Münch recommends a still further distribution of blasting charges, and calculates that to have done the same work with 17 boreholes, each containing two charges, would have cost £88, or about 1·9d. per cubic yard.

He also maintains that with charges thus reduced the shattering effect of the explosion would be considerably lessened. A. R. L.

EXPERIMENTS WITH GUIBAL FANS.

Ueber Grubenventilatoren nach Daniel Murgue und der Guibal-Ventilator zu Comberedonde. MÄHR-OSTRAU CLUB. *Vereins-Mittheilungen, Beilage zur oesterreichischen Zeitschrift für Berg- und Hüttenwesen,* 1883, *pp.* 4–7.

PARTICULARS OF FAN.

Diameter	29 feet 6 inches
Breadth	6 „ 7 „
Revolutions per minute	45
Theoretic height of water-gauge	2·08 inches.
Density of atmosphere being taken at	1·15

PARTICULARS OF ENGINE.

Diameter of piston	19¼ inches.
Length of stroke	1 foot 7¾ inches.

PARTICULARS OF AIR MEASUREMENT.

Section of air passage at fan inlet	8·93 sq. yards.
Section in the pit	5·28 „

No.	Observations.				Results of Calculations.				Density of the Air.		Manometric Performance.			Performance of Machinery		
	Revolutions per Minute.	Volume of Air per Second in Cub. Ft.	Gauge Depression in Inches.	Mean Pressure on Cylinder in Lbs.	Equivalent Section in Sq. Yards.	Volumes corresponding to 45 Revolutions.	Depression corresponding to 45 Revolutions.	Useful Effect with 45 Revolutions.	At Bank.	In the Pit.	Measured Depression in Inches.	Theoretic Depression in Inches.	Coefficient of Performance.	Effective Horse-power.	Indicated Horse-power.	Coefficient.
1	41·14	462	1·10	29·5	1·11	505	1·34	6·51	1·207	1·150	1·34	2·07	·647	4·97	9·90	·502
2	42·58	644	1·22	38·2	1·47	681	1·37	9·00	1·200	1·134	1·38	2·05	·672	7·62	13·22	·576
3	49·44	1,111	1·49	73·7	2·31	905	1·23	11·96	1·195	1·137	1·23	2·05	·601	15·86	29·62	·533
4	43·60	1,525	·20	85·1	8·66	1,574	·21	3·23	1·189	1·172	·21	2·11	·101	2·94	30·13	·097
5	52·54	605	1·83	51·1	1·12	520	1·35	8·84	1·181	1·118	1·35	2·02	·670	13·97	21·76	·642

The fan outlet was adjusted to suit No. 2 experiment, and kept the same throughout the trials.

Experiments with a Guibal Fan at the Crachet et Picquery Colliery in the Year 1865.

Diameter of fan, 23 feet; breadth of fan, 5 feet 7 inches.

Condition of Ventilator, Date, and Number of Experiment.	No. of Revolutions.	Effective Work on the Piston in H.P.	Air drawn per Second in Cub. Ft.	Depression at Fan Inlet in Inches.	Work due to the Drawing of the Air in H.P.	Proportion of Power Employed to Useful Work.	Remarks.
No. 3. The blades taken off. House not yet built.	18·75	1·40	...	...	...	...	To determine friction of machinery.
	30·50	2·80	...	...	...	...	
	50·50	9·01	..	...	...	...	
	75·00	24·80	...	...	...	...	
No. 4. House partly built. Ventilator mounted, but without blades.	19·25	2·37	...	...	...	...	Diagrams from bottom of cylinder.
	30·00	3·52	...	...	...	...	
	48·50	6·80	...	...	...	...	
	87·50	20·46	...	...	...	...	
	87·00	27·00	...	...	...	...	Diagrams from top of cylinder.
	19·75	2·26	...	...	...	...	
	51·00	9·86	...	...	...	...	
	84·50	24·80	...	...	...	...	
No. 1. Blades in place. House not built. Air from shaft shut off.	16·00	1·30	...	·14	...	...	Experiments on depression at different speeds with and without the house.
	20·00	1·87	...	·20	...	...	
	29·50	4·26	...	·31	...	...	
	40·00	6·50	...	·49	...	...	
	49·50	10·94	...	·69	...	...	
	60·00	18·31	...	1·04	...	...	
	67·00	25·06	...	1·42	...	...	
	72·00	31·06	...	1·61	...	...	
No. 5. House built, but without adjusting slide. Air from shaft shut off.	39·00	5·36	...	·43	...	...	
	43·00	8·00	...	·71	...	...	
	72·00	21·34	...	1·70	...	...	
	82·00	33·00	...	2·13	...	...	
	90·00	38·38	...	2·56	...	...	
No. 6. Blades in place. House built except vent. Air being drawn from pit.	43·00	11·77	201	·57	1·10	·09	In the case where 93 revolutions were obtained a door was opened 18 inches square.
	57·00	19·40	310	1·10	3·27	·17	
	70·00	28·68	433	1·54	6·37	·21	
	93·50	59·22	636	2·81	17·17	·29	
	93·00	64·41	735	2·81	19·80	·31	
No. 2. Ventilator complete. Air being drawn from pit. House not built.	30·50	4·80	235	·33	75	·16	Door open.
	38·50	8·53	...	·59	...	...	
	53·00	17·22	337	·94	3·05	·18	
	63·10	26·34	...	1·30	...	...	
	72·00	37·88	...	1·69	...	...	
	76·50	44·24	517	1·93	9·57	·22	
No. 7. Fan drawing from pit. House and vent built, but without slide.	41·00	7·45	305	·67	1·95	·26	Experiments to determine influence of vent.
	61·00	17·94	497	1·57	7·50	·42	
	88·00	47·00	838	3·33	26·70	·57	
	84·00	47·00	1,040	3·11	31·02	·57	
	101·00	47·00	1,040	4·49	31·02	·57	
No. 8. Everything complete. Slide with 6 inches opening.	68·00	18·66	...	1·26	...	...	
No. 9. Slide in most effective position = 25¼ inches opening.	68·00	20·10	...	1·93	...	...	

A. R. L.

NEW SAFETY-LAMP.

Unexplodirbare Sicherheitslampe. PROFESSOR V. CURTER. *Vereins-Mittheilungen, Beilage zur oesterreichischen Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 45–46.

Professor V. Curter is the inventor of a safety-lamp, which he believes to be much safer than any of those in use. The construction is such that the air in its passage to and from the light must pass either through several coils of spirally wound copper wire or through a system of brass plates placed parallel to each other and very close together, the usual wire-gauze cylinder giving way to one of glass. The lamp is so contrived that the act of opening it puts the light out. In connection with this subject, an apparatus is described called the Anselm Indicator, which is a kind of manometric balance, and will indicate the presence of dangerous quantities of gas, by means of the varying specific gravity of the atmosphere. The indicator has electric connection with an alarm bell which rings when the arm of the balance falls so low as to indicate danger.

A. R. L.

IMPROVEMENTS IN MINING METHODS.

Verbesserungen bei den bergmännischen Gewinnungsarbeiten. PROFESSOR ROCHELT. *Vereins-Mittheilungen, Beilage zur oesterreichischen Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 39–41.

The Professor mentions some improved methods of blasting, and describes several boring and coal-cutting machines used in Saarbrücken, Westphalia, and other mining centres. The driving of air passages with the pick has been superseded in these districts by the use of hand machines, which can bore cylindrical holes of from 10 to 20 inches in diameter. The machines of Wegge and Pelzer, Gildemeister, and Munscheid and Hussmann are specially mentioned and described. That of Wegge and Pelzer, for holes from 12 to 14 inches in diameter, is worked by two men at a time, each turning a handle, and when worked by four men, in relays of two, will penetrate, according to the hardness of the coal, from 120 to 145 yards per shift of 10 hours. The machine of Munscheid and Hussmann also requires two men to work it, and with ordinary hardness of coal will bore a 20½-inch hole at the rate of 1·09 yards per hour. With holes of 11¾ inches in diameter the cost of boring is given as about 1s. 4½d. per yard. The ordinary sizes are for holes of 14½ inches, 16½ inches, 18½ inches, and 20½ inches respectively, and the first cost of a machine is about £35.

A comparison is made between hand kirving and that done by cutting machines. A "Reska" machine working in a 27 to 29-inch seam in the Ostran pit will kirve a surface of 48 square yards, the depth of the cut being 2·952 feet and the width 3·15 inches, a hewer being able to kirve a surface of 1·8 to 2·15 square yards in the same time, with a depth of cut of 2·9 feet and a width of 11¾ inches. The machine work shows a saving of 2¾d. per cwt. of coal worked, and, at the same time, an increased proportion of round coals to the extent of 10 per cent., the whole gain being about 3d. per cwt.

Reference is made to the use of compressed blasting powder in Prussian Silesia with good results. In the Laura pit, Upper Silesia, a blasting cartridge is in use which, with an increased fall of coal of about 5 to 6 per cent., shows a saving in powder of 23 per cent. Its peculiarity lies in the fuse being introduced into the charge through a perforated paper case, about 20 inches long by ¼ inch inside diameter. It is considered that the ignition of the powder is by this method more complete, and that the explosion takes place more nearly instantaneously. A. R. L.

PRODUCTION OF ZINC.

Zur Geschichte des Zinkes. REGIERUNGSRATH ERNST. *Vereins-Mittheilungen, Beilage zur oesterreichischen Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 44–45.

This gives a history of zinc from early times, and shows its production to have greatly increased during the last quarter of a century. The figures are as follows:—

	1858. Cwts.	1881. Cwts.
Silesia	380,000	675,470
Rhine districts and Westphalia ...	154,000	325,200
Belgium, Vieille Montagne Works ...	270,000	496,000
Do. other works	95,000	442,110
England	75,000	151,860
France	5,000	104,450
Spain	15,000	70,320
Austria	10,500	42,300
Russia	15,000	43,000
North America	—	300,000
Total...	1,019,500	2,650,710

A. R. L.

SILVER AMALGAMATION.

Anfang und Ende der europäischen Silberamalgamation. PROFESSOR V. CURTER. *Vereins-Mittheilungen, Beilage zur oesterreichischen Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 21–22.

The extraction of silver from the ore by means of quicksilver, which had been practised in Austria from very early times, was revived in the year 1570 by Johann de Cordova, his method being borrowed from America.

The ore was ground fine in a mill and mixed with salt, copper vitriol, and iron vitriol. It was then damped and left lying till it became warm, when it was strewed with quicksilver and well mixed. This process being completed, fresh quicksilver was added, which, by combination, took up the amalgam crystals. The amalgam was then filtered, put into leather bags and pressed, and finally smelted.

Just 100 years ago Bergrath von Born introduced, at Glashütten, near Schemnitz, a method differing slightly from the foregoing, and this was followed till it gave way to newer modes of working some 25 or 30 years ago. A. R. L.

TRANSCAUCASIAN MANGANESE DEPOSITS.

Gisements de Manganèse de la Transcaucasie. *By* J. Reuleaux. *Annales de l Société Géologique de Belgique, Vol. IX.*, 1883, *pp. cxxxviii.-cxlii.*

The manganese deposits described in this paper are situated in the neighbourh of the village of Tchiatura, about 40 versts from the Koirile Station on the Poti-Ti Railway, in the Government of Kutaïs. They occur as compact, hard, or oolitic mas forming thin beds in the upper portion of the Eocene, where the latter passes ins sibly into Miocene. There are nine of these beds, having a total thickness of 8 metres, and they alternate with talcose or manganesiferous clay. Analyses of f varieties of these ores show the following composition:—

	1.	2.	3.	4.	5.
H_2O	2·40	1·61	1·20	0·74	1·26
SiO_2	4·49	6·67	2·88	0·74	1·69
Al_2O_3	1·68	2·14	2·34	1·12	1·27
Fe_2O_3	0·53	0·03			0·26
MnO_2	85·67	85·77	84·90	94·32	91·23
MnO	1·98	0·80	2·50	1·82	2·40
CaO	0·76	0·87	0·33	traces	0·58
MgO	0·20	0·24	0·32	0·20	0·31
BaO	0·88	0·68	3·11	traces	traces
SO_3	—	—	1·19	—	—
Ph_2O_3	0·42	0·40	0·35	0·06	0·08
Total	99·01	99·21	99·12	99·00	99·08

The deposits were formed, the author thinks, in a shallow sea, near coasts wh periodical currents were common. G. A. L.

GOLD IN BORNEO.

Das Goldvorkommen von Borneo. *By* Theodor Posewitz. *Jahrbuch d. k. ung Geol. Anstalt, Buda-Pesth, Vol. VI.*, 1883, *pp.* 175–190.

A general account of the distribution of gold in Borneo. The auriferous depo are of three kinds—alluvial, diluvial (drift), and massive rock. The first, for ages p worked by the natives, are now much reduced in value, but were once of great ext following the course of all the rivers of the country. The second, or drift depos are at present the richest in the island, and are chiefly worked in West Borneo, betw the Rivers Landak and Sambas. They are generally concealed by a covering from t to ten feet thick of clay or loam, and themselves vary in thickness from a few inc to between 30 and 40 feet in places. They consist principally of quartzose sand, mi occasionally with fragments of greenstone, syenite, and gabbro. The gold found these sands is associated with platinum, diamonds, magnetite, and chromite. Und lying the gold drift beds is almost invariably a layer of clay due to the weathering the massive rocks beneath, and containing no precious metals.

The gold, both of the alluvium and drift, is, of course, derived from the older roc and in these—though sparingly—it is still found. Thus it occurs disseminated metamorphic schists, and even in granite as well as in quartz veins, in the more us manner. It is also common in various proportions associated with iron and cop pyrites, zinc blende, tenorite, and tellurium in copper and other lodes.

G. A. L.

GOLD AND SILVER IN THE UNITED STATES.

Production of the Precious Metals. By CLARENCE KING. *Second Annual Report of the United States Geological Survey to the Secretary of the Interior, for* 1880–81. *Washington*, 1882, *pp.* 337–401. *Six Plates* (*Pl.* xlviii.–liii.)

The author groups the gold and silver mines of the country under two heads—deep mines and placer mines. The former comprise:—1.—Mines of free gold, or of gold alloyed with a small proportion of silver. 2.—Mines of silver ores, containing only traces of gold. 3.—Mines yielding *doré* bullion from milling ores containing both gold and silver in appreciable quantities. 4.—Mines yielding base bullion from smelting ores, in which the precious metals are associated with larger quantities of lead, copper, etc. The leading types of the placer or drift and alluvium diggings are (1) hydraulic mines; (2) dry washings; (3) booming and shovel-sluicing; (4) river mines; (5) pocket mines; (6) drift mines; (7) branch mines; (8) black sand littoral deposits. Full statistics of the production of the precious metals for the census year (June 1st, 1879, to May 31st, 1880) are then given by geographical divisions. Summarized, these tables give the following results:—

	Gold. Dollars.	Silver. Dollars.	Total. Dollars.
Pacific division	25,261,828	21,143,881	46,405,709
Rocky Mountains division...	7,878,189	19,917,490	27,795,679
Eastern division	239,646	49,586	289,232
Total	33,379,663	41,110,957	74,490,620

In converting United States money into Troy weight it should be remembered that for gold, 1 dollar = 0·048374957925 ounce Troy, and 1 ounce Troy = 20·671834 dollars. For silver, 1 dollar = 0·773455023513 ounce Troy, and 1 ounce Troy = 1·2929 dollar.

Comparing the annual bullion production of the great divisions of the world, North America stands first with 55·78 per cent. of the total product, Europe, including Russia in Asia, next with 21·75 per cent., then Australia with 15·93, South America with 4·68, Africa 1·10, and Japan with 0·76 per cent.

Altogether seventy-two tables are given, and the information contained in them is also shown graphically in the plates which accompany the report. G. A. L.

IRON ORES OF VIRGINIA.

The Iron Ores of Middle James River. By DR. PERSIFOR FRAZER. *Transactions of the American Institute of Mining Engineers, Vol. XI.*, 1883, *pp.* 201–216. *Two Plates (contoured Map and Section).*

The ore district described comprises that portion of the ferriferous belts of Virginia which lies between Josua Falls and Norwood, in Amherst and Nelson Counties, on the left bank of James River. The ore-bearing rocks are probably the same in geological horizon as part of the great iron series of the Northern Peninsula of Michigan. They are probably of Huronian age. The ores show ample evidence of having been deposited by metasomatic action among the schists which enclose them, and they are frequently cut off by intrusive masses ("chutes") of quartz. A general description of the works of the Central Virginia Iron Company is given, as well as a large number of analyses of ore from this region, and also from that of Marquette, for comparison.

G. A. L.

THE BASSICK MINE, COLORADO.

On the Peculiar Features of the Bassick Mine. By L. R. GRABILL. *Transactions of the American Institute of Mining Engineers, Vol. XI.*, 1883, *pp.* 110–117.

This mine is six miles east of Silver Cliff, Colorado, and is situated near the centre of a small rounded hill of eruptive trachyte and felspathic conglomerate. The chief peculiarities of the ore deposit are as follows:—The ores (gold and silver), instead of being as usual arranged in layers more or less parallel to the vein walls, are found disposed in concentric coats surrounding what are regarded as waterworn pebbles or boulders of the same material as the country rock (trachyte), each ore in a separate layer, and always in the same order. The first—next to the nucleus—is the thinnest layer, and consists of ½ to 1 millimetre, on an average, of mixed sulphides of zinc, antimony, and lead, carrying about 60 ounces of silver and 1 to 3 ounces of gold per ton. The second coating is not always present, but when it occurs contains more lead, silver, and gold than the first, often 150 to 200 ounces of silver and 100 ounces of gold per ton. The next shell is 5 millimetres to 5 centimetres thick, and consists of sphalerite in fine crystals; it yields from 60 to 120 ounces of silver and 15 to 50 ounces of gold per ton, and forms the most valuable part of the mine. The fourth, and generally the last coat when present, is of copper pyrites, 1 to 2 centimetres thick. It carries as high as from 50 to 100 ounces per ton of silver, and about as much of gold. A fifth layer sometimes occurs, formed of a sprinkling of crystals of iron pyrites. Kaolin fills in the interstices between the ore-coated boulders, and therefore none of the ordinary spars of metalliferous veins, except some quartz, which, with tetrahedrite, is found occupying spaces outside the boulders. This quartz is such as might have been deposited in a gelatinous state, and, with the other exceptional facts connected with the deposit, leads the author to regard the latter as having been the seat of a geyserian mineral spring. The shape and dimensions of the fissure, or more properly "opening," containing the ore-boulders, as well as its verticality, favour this view. Still more striking among all the singular features of the mine is the presence of charcoal in cavities or pockets between the ore-coated boulders. This substance occurs at all depths. The last pocket of it was found at 765 feet from the surface, equal in size to a cube with an edge of 30 centimetres, and the charcoal showed the grain of the original wood distinctly. G. A. L.

GOLD IN CRETACEOUS ROCKS.

On the occurrence of Gold in Williamson County, Texas. By PROFESSOR CHARLES A. SCHÆFFER. *Transactions of the American Institute of Mining Engineers, Vol. XI.*, 1883, *pp.* 318–321.

This is the first record of the occurrence of gold in Cretaceous rocks in the United States. It was found irregularly disseminated in a bed of porous limestone of that age. The gold was introduced into the rock, the author thinks, in the condition of auriferous iron pyrites. The decomposition of the latter and of the limestone gave rise to calcium sulphate, which, being worked out, caused the porous character of the stone, leaving the gold and some of the brown oxide of iron entangled among its crevices. The amount of gold found is moderate only, and some parts of the bed of limestone, though otherwise similar to the rest, contain none at all. There is a tradition that the Mexicans in former time worked the rock for silver, which it does not yield. G. A. L.

GILPIN COUNTY MINES, COLORADO.

The Mines and Mills of Gilpin County, Colorado. By COL. A. N. ROGERS. *Transactions of the American Institute of Mining Engineers, Vol. XI.*, 1883, *pp.* 29–51.

These mines occupy a limited area of a few miles in the immediate neighbourhood of Central City. Altogether, within this area, some 400 miles of veins are recorded. The country rock is said to be metamorphic granite, in which the planes of bedding are well marked, and in which two constant directions of vertical joints are everywhere developed. The veins or lodes occupy these joints, and no faulting of importance is known in the district. The vein-stuff consists generally of felspathic quartz, through which are disseminated fine pyritous matter, as well as "masses, seams, and strings" of of the various ores characterizing the veins. Cavities in the vein-stuff are lined with quartz crystals, having their long axes parallel to the cheeks. The country rock shows no perceptible change on approaching the veins. The latter are gold and silver bearing, these precious metals being found in very various associations, thus:—"One lode may carry its value in copper, another in iron, the next in blende, the fourth perhaps in gangue or in galena."

The concluding part of the paper comprises an account of the methods of treating the ores in use in the district, and the discussion which follows (pp. 51–55) bears chiefly upon this portion of the subject. G. A. L.

THE SAN JUAN MINING REGION, COLORADO.

Notes on the Geology and Mineralogy of San Juan County, Colorado. By THEODORE B. COMSTOCK. *Transactions of the American Institute of Mining Engineers, Vol. XI.*, 1883, *pp.* 165–191, *with Map, and two Woodcuts in text.*

San Juan County comprises a portion of the hydrographic basin of one branch of the Colorado River, and includes all the upper ramifications of the Animas, with small areas at the sources of the Rio Grande, and of branches of the Gunnison River. The lowest ground is about 8,500, and the highest 13,975 feet above sea level. The oldest rocks of the country are probably of Silurian and Devonian age, and are chiefly granites and quartzites, which together form a Metamorphic series of importance. These are succeeded by comparatively small outcrops of shales, limestones, and thick red sandstones of Carboniferous age. Triassic, Jurassic, and Cretaceous beds are not known in the region, but the Tertiary age is strongly represented by a widely-distributed series of volcanic rocks, which may be grouped as follows (the first-named being the oldest):—Propylite, andesite, trachyte, rhyolite, and basalt. Hot-spring deposits of later date form a characteristic feature of some parts of the district.

The great majority of the mineral veins of San Juan County basset in the Tertiary trachyte, but others are known (including some of great value in the Metamorphic and Upper Palæozoic rocks). They are, in the author's opinion, nearly all of post-Tertiary origin, and date from the first occurrence of the hot springs. The courses of the lodes bear no relation to the trend of the principal folds in the old rocks. All the important veins, on the contrary, are said to be arranged in a radiating manner round certain prominent local foci—which, though "geological vein centres," and often actual peaks (such as Handie's Peak, Kendall Mountain, Red Peak, etc.), do not by

any means always coincide with topographical prominent points. The cause of this distribution of the veins is connected with the central localities of trachytic eruption. Thus Red Peak, which is the main centre towards which the primary lodes converge, is situated where the main outbreak of trachytic lava took place.

The most prevalent ores are galena, iron, and copper pyrites, bismuth compounds, and tetrahedrite. Native silver sometimes also occurs, as well as ruby silver and compounds of antimony and tellurium. The ordinary vein-stuff is quartz, but calcite, barite, hæmatite, and fluor spar are also present occasionally, the last named being least commonly met with.

"The large deposits which are now causing the great rush to the Red Mountain district are, in my opinion," says the author, "the representatives of the latest epoch of vein growth, and they must be regarded as occupying caverns left by extensive hot-springs. On this account they will, I judge, be found to be quite irregular in position and dimensions." (p. 190.) G. A. L.

NATURAL COKE (CARBONITE).

The Natural Coke of Chesterfield County, Va., by Dr. R. W. Raymond; and *Chemical Examination of Carbonite, by* Dr. T. M. Drown. *Transactions of the American Institute of Mining Engineers, Vol. XI.,* 1883, *pp.* 446–450.

In 1882 a mine was open near Midlothian, Chesterfield County, Va., to work a seam of which the following is a section:—

		Ft.	In.
Whin rock (not igneous apparently)		2	6
Hard arenaceous shale		6	0
Dark shale, with laminæ of coal		1	0
Carbonite	carbonite or coke seam	2	0
Dark shale		1	0
Carbonite		2	3
Dark shale		1	3
Carbonite		1	9
Shale		0	1
Carbonite		9	0
Fire clay		0	8
Thin layers of whin rock occasionally (apparently not igneous)		0	3

A thick seam of highly bituminous coal is said to occur beneath the coke seam, and to have been extensively worked in a neighbouring property. The coke seam has been followed 325 feet to the dip; it burns like anthracite, without smoke or soot. No eruptive rock is reported as occurring in proximity to the seam. The analysis (proximate) of the carbonite is thus given:—

	Dull Portion.	Lustrous Portion.
Specific gravity	1·375	1·350
Loss at 100° C.	2·00	0·69
Volatile matter	15·47	11·10
Ash	3·20 (dark brown)	6·68 (white).
Fixed carbon	79·33	81·53
	100·00	100·00
Sulphur	4·08	1·60

G. A. L.

THE PENNSYLVANIAN ANTHRACITE FIELD.

The Anthracite Coal Beds of Pennsylvania. By CHARLES A. ASHBURNER. *Transactions of the American Institute of Mining Engineers, Vol. XI.*, 1883, *pp.* 136-159, *with one folding Plate.*

The author, who is in charge of the Second Geological Survey of the Anthracite Coal-fields of Pennsylvania, gives an account of the organization, methods, and publications of the survey. The latter include:—1.—Mining maps on a large scale (800 feet = 1 inch), showing mine workings, and the lie of the seams by means of underground contour lines, 50 feet apart. 2.—Topographical surface maps of the coal-fields (1.600 feet = 1 inch) contoured every 10 and 20 feet. 3.—Vertical cross sections of the coal basins (400 feet = 1 inch). 4.—Columnar sections of the Coal-Measures (40 feet = 1 inch). 5.—Columnar sections of individual coal-seams (10 feet = 1 inch). 6.—Other miscellaneous sheets.

Type sections at the more important points of the region are given, illustrating an attempt to correlate the principal seams, the different so-called "basins" selected being the following:—Pottsville, Panther Creek, Shamokin, Shenandoah and Mahanoy, Hazleton, Black Creek, Nanticocke, Wilke's Barre, Lackawanna, and Carbondale.

A new estimate (and the most accurate up to date) of the areas of the coal-fields in question is given, viz.:—

	Square Miles.
Northern Coal-field	198
Eastern Middle Coal-field	37
Western " "	91
Southern " " (exclusive of Panther Creek)	130
Panther Creek Basin	12·5
Total area	468·5

The total production of coal in this region up to and including 1881 is estimated at 478,052,629 tons. G. A. L.

ALABAMA COAL AND IRON.

Coal and Iron in Alabama. By DR. T. STERRY HUNT. *Transactions of the American Institute of Mining Engineers, Vol. XI.*, 1883, *pp.* 236-248.

The rocks of the state are grouped in four divisions as follows:—1.—The old crystalline rocks of the Atlantic belt, along the south-east side of the Coosa Valley, containing occasional deposits of magnetite. 2.—The Ocoee slates and conglomerates, the Chilhowee sandstones, and the Knox Group rocks, including great deposits of limonite and oxide of manganese, all in the Coosa Valley. 3.—The Palæozoic rocks, between the last and the Upper Carboniferous, including Silurian beds belonging to the Clinton group, and containing great beds of red hæmatite. 4.—The Coal-Measures. These are as thick here as in Pennsylvania, and contain many coal-seams of sufficient thickness for profitable working and of excellent quality, especially in the Warrior and Cahaba fields.

The proximity of the iron ore to the coal is dwelt upon by the writer as being (with the exception of the north-western portions of the great Ohio basin) very unusual in the United States, and he adds:—"The development in Central Alabama, not only of a great coal-trade, but of a vast iron industry, is certain in the near future, and indeed has already begun." (p. 247.) G. A. L.

MINING IN ARIZONA.

The Mining Region around Prescott, Arizona. By JOHN F. BLANDY. *Transactions of the American Institute of Mining Engineers, Vol. XI.*, 1883, *pp.* 286–291, *with folding Map.*

The writer deplores the absence of maps of Arizona, and gives the one accompanying his paper as a rough contribution to the topography of part of the region. The Prescott district comprises the very high ground about the head waters of the Hasayampa, Aqua Frio, and Granite Creeks, and their upper tributaries. The rocks of the country between the Peck Mine and Prescott are described. They consist of granite, syenitic gneiss, and hornblende slates and schists, with trap dykes and sheets of basalt. Most of the veins in the granite and schists have directions varying from N. 20° E. and S. 20° W. to N. 20° W. and S. 20° E. Some veins, called "layer" veins, appear to be contact deposits of limited extent, coinciding with the bedding planes of the rocks. The veins are gold and silver bearing, often very rich, and are remarkable for the large amount of horn-silver (silver chloride) which some of them contain. A great variety of sulphides and other ores accompany the precious metals, and there are rich placer workings due to the decomposition and disintegration of the lodes by weathering and denudation.

This short paper gives almost the first published account of what is practically a new mining region. G. A. L.

THE SEMET COKE OVEN.

Fours à coke du système Semet pour la récupération des sous-produits. Par CH. DEMANET. *Annuaire de l'Association des Ingénieurs Sortis de l'École de Liége, Tome II.*, 1883, *pp.* 105–114. *One folding Plate.*

The author describes the construction and action of the oven in detail, and gives the results of experiments made at the Bellevue Colliery, Dour, near Mons, in December, 1882, and some later experiments made at Creusot.

The trials at Creusot were made upon two samples of coal composed as follows:—

	No. 1.	No. 2.
Bituminous	62 ...	60
Semi-bituminous	19 ...	20
Anthracite	19 ...	20
	100	100

An analysis of which gave:—

	No. 1.	No. 2.
Water (from washers) ...	9·65 ...	9·75
Volatile substances	20·35 ...	20·08
Ashes...	11·00 ...	10·66

The following results were obtained after coking 50 tons of each of the above samples:—

Yield per Ton of coal (dry).	No. 1.	No. 2.
Coke (dry)	80·07% ...	75·51%
Ammoniacal liquor at 1° Baumé... ...	4·08 hect ...	3·00 hect.
Tar	26·09 kil. ...	15·08 kil.

This is equal to—

Ammoniacal liquor ...	89·8 and 66 galls. respectively.
Tar	59·18 and 34·76 lbs. ,,

J. H. M.

EXPERIMENTS ON A NEW VENTILATING FAN.

Résultats d'expériences sur un nouveau système de ventilateur à force centrifuge. Memoire de M. L. SER, *présenté par* M. TRESCA. *Comptes Rendus, Tome XCVIII., pp.* 783–786.

In 1878 the author published a theory of centrifugal fans, in which he deduced certain formulæ which are quoted in this paper. Several fans have been constructed in accordance with these, and experiments have been made upon two of them by M. Tresca, at the Conservatoire des Arts et Métiers.

A table is given showing the results, and his conclusions are quoted as follows:—

1.—There is a complete agreement between the theory and practice.

2.—The ratio between the water gauge observed and the water gauge due to the velocity of the periphery varies from 1·855 to 2·368.

3.—The volume of air discharged is practically the same as that given by the formula, and is equal to about ten times the volume engendered by the blades.

4.—The useful effect varies from 0·604 to 0·828. J. H. M.

RESUMÉ OF FIRE-DAMP ACCIDENTS IN FRANCE.

Analyse Synoptique des Rapports Officiels sur les Accidents de Grisou en France. Par MM. JULES PETITDIDIER *et* CHARLES LALLEMAND, *Ingénieurs au Corps des Mines. Annales des Mines, Sér.* 8, *Tome IV.*, 1883, *pp.* 67–127.

The present group of accidents comprises those of the Loire district—St Etienne coal-basin—which are officially numbered from No. 169 to No. 251, a total of 82 accidents. The first is registered on May 25th, 1840, and the last on the 11th January, 1877. The most serious appears to have been No. 250, on the 4th February, 1876, at the Jabin pit, when 186 perished and 12 were injured. This explosion appears to have been very disastrous, extending through every part of the mine. Out of 211 men at work in the day shift only 28 were rescued alive, and of these three subsequently succumbed. The cause of explosion is officially notified as "lucifer matches or spontaneous fire" (rather a wide divergence apparently); but the authors, in their remarks, state the following as their views:—"Coal-dust appears to have played a certain part in the accident, the direction in which the crusts of coke were deposited on the timber appearing to indicate that the flame came from the Treuil district to the Jabin pit, from the central district to the double shaft, and from the Richelandière workings to the Jabin pit. The seat of the explosion must have been in the Treuil district, the only part of the mine whence the flame appears to have issued in two opposite directions. As for the cause of the accident, it has remained unknown. . . . . The Mueseler lamps could only be opened by an electro-magnet, and were subjected to rigorous scrutiny, and nothing indicates that they had been tampered with previous to the accident. . . . . Shooting was only permitted in stone drifts, and shots fired by the under-viewer only. This last regulation was not always observed, but no stone work was in progress in the Treuil district at the time of the explosion. The least improbable theory is that some workman had obtained a light for smoking. . . . . It is also possible that the sudden fall in the barometer noted on the day of the accident may have liberated a quantity of fire-damp from the old workings."

The series has to be completed in a later contribution to the *Annales des Mines*, when an abstract will probably enable a summary to be given of the number of lives lost, and a classification of the different heads of causes of explosion, etc.

D P. M.

ANALYSIS OF THE OFFICIAL REPORTS ON THE COAL GAS EXPLOSIONS IN FRANCE.

Analyse des Rapports Officiels sur les Accidents de Grisou, survenus en Franc pendant l'anné 1881. *Dressée par* M. CHESNEAU, *Ingenieur au Corps de Mines. Annales des Mines, Sér.* 8, *Tome IV.*, 1883, *pp.* 215–237.

This paper is a continuation of the report by MM. Petitdidier and Lallemand, bu confines its notices to the year 1881. Sixteen explosions occurred during the abov year in France, the casualties being 23 deaths and 33 injured. One was peculiarl painful, resulting in the death of one of the Government inspectors, the viewer, an two others (one a foreign mining engineer), who were inspecting the scene of previous disaster.

ABSTRACT OF ACCIDENTS IN 1881.

District.	Name of Colliery.	No. of Sufferers.		Supposed Cause of Accident.
		Killed.	Injured.	
Nord and Pas-de-Calais	Douchy	4	5	Outburst consequent on a shot being fired.
	Anzin	...	7	Gas lighted by blown out shot.
	L'Escarpelle ...	1	4	Supposed defective lamp; loose cartridges ignited near.
	Hardinghen ...	...	2	Naked lights; gas issued from borehole in exploring drift over old workings in lower seam.
Loire ...	Roche la Molière.	8	3	Gas fired by shot.
	Le Cros	1	...	Naked lights in winning drift.
	La Béraudière ...	...	3	Gas fired by shot.
	Quartier-Gaillard	1	...	Gas fired while lighting shot.
	Plat-le-Gier ...	...	4	Gas fired by shot.
	Trélys et Palmesalade ...	...	1	Gas fired while lighting shot.
Gard ...	Trélys et Palmesalade ...	...	1	Naked light.
	Do. ...	...	2	Gas fired while lighting shot.
	Portes et Sénéchas	...	1	Gas fired by shot.
Saint-Eloi ...	La Vernade ...	2	...	Naked lights; outburst of gas in proximity to standing fire.
Champagnac	Lampret ...	1	...	Slackening or stoppage of air current; naked light.
	Do. ...	5	...	Same cause, but Mueseler lamps used; exploring locality of previous accident.
		23	33	

The above are grouped as follows:—

		No. of Accidents.	Killed.	Injured.
Shot firing	While lighting ...	4	9	6
	By shots	5	4	20
Defect in local ventilation	Naked lights ...	5	4	3
	Safety lamps ...	2	6	4
	Total	16	23	33

Shot firing thus appears to have been the chief ingredient in fatal results, only two accidents being traced to carelessness, and those in the second category. D. P. M.

EXPERIMENTAL AND THEORETICAL ESSAYS ON THE COMBUSTION OF EXPLOSIVE MIXTURES OF GASES.

Recherches expérimentales et théoriques sur la combustion des mélanges gazeux explosifs. Par MM. MALLARD *et* LE CHATELIER, *Ingénieurs au Corps des Mines. Annales des Mines, Sér.* 8, *Tome IV.*, 1883, *pp.* 274-378.

The Fire-damp Commission, of which the authors were members, entrusted them with the duty of discovering, by suitable experiments, the conditions under which fire-damp explosions occurred, and their accompanying phenomena. They accordingly investigated the following questions, of which the two first are treated in this part:—

1.—The conditions necessary to produce active combustion, *i.e.*, the *temperature of ignition.*

2.—The *rapidity* with which ignition at one point is propagated throughout the inflammable mixture, and the accompanying circumstances.

3.—The *pressure* produced in a closed vessel after combustion of the gaseous mixture contained in it, computing the *law of cooling*, the temperature of combustion, and the alteration produced by high temperatures on the *specific* gravity of gases.

Only a few observations were made on each of these subjects owing to the many difficulties to be overcome.

Question 1 is sub-divided into the following heads:—

1.—History.
2.—Modes and apparatus.
3.—Results of experiments.
4.—Conclusions from ditto.
5.—Summary.

The whole of these five branches are most exhaustively treated from the time of Davy until the present, and many interesting points are elucidated, amongst which may be noted the opinion of the authors that red hot substances, such as lamp gauzes, tobacco, &c., may become causes of ignition under certain conditions by no means unusual. The inflammation of explosive mixture thus depends on two factors—the temperature and the duration of contact.

In the summary the temperatures are given as

555° (= 825° F.)	explosive mixture of	hydrogen and oxygen.
655° (= 968° F.)	"	carbonic oxide and oxygen.
650° (= 960° F.)	"	formène and oxygen.

The formène is almost identical with the light carburetted hydrogen or fire-damp of mines.

Question 2 includes the following divisions:—

1.—History.
2.—Modes of experimenting.
3.—Results.
4.—Theoretical considerations.
5.—Practical applications.
6.—Summary.

The ignition of a body of explosive mixture is traced to two causes, one being termed *conductivity* or normal propagation, and the other *wave of explosion*, discovered by MM. Berthelot and Vieille. Each of these modes is characterized by a constant and specific velocity of propagation under the same conditions of mixture and temperature. The former never exceeds, if it ever reaches, 66 feet (20 metres) per second.

The usual velocity in a mixture of fire-damp and air is only 2 feet per second wh the fire-damp is from 9 to 12 per cent.; that in hydrogen and oxygen (40 per cent. hydrogen) being 14 feet (4·30 metres); ordinary lighting gas, 4 feet 2 inches (1·2 metres), with 15 per cent. of gas; and carbonic oxide and oxygen 6 feet 6 inch (2 metres) per second. Any disturbance in the gaseous mixture increases the rapidi of propagation. The initial velocity gradually increases on account of vibrations oscillations which increase the intensity as well as the rapidity of propagation, a when this occurs a continuous pressure is transmitted from layer to layer and t explosive wave is formed.

Some very interesting experiments were also made by the authors on safety lam and on the means of detecting minute percentages of fire-damp. D. P. M

NOTES ON THE DUFOUR CONPENSATING LEVER FOR RAILWAY SIGNALS.

Note sur le Compensateur Système Dujour. Par M. SCHLEMMER, *Inspecteu Général des Ponts et Chaussées. Annales des Mines, Sér.* 8, *Tome IV.*, 188 *pp.* 128–132.

This paper, although short, contains a good description of an apparatus designed obviate the torsion between lever handles and signal posts on railways. The figur illustrating it are on Plate V. (figs. 13, 14, 15, and 16). The Lyons Railway Compa have adopted this system with great success. The idea appears to be the replacement the usual round arms or connections by one of an elliptical form, which only comes in play when the line is entirely clear or free, the signal remaining at "stop" or "dange even when obstruction in the levers might in usual cases prevent proper working.

D. P. M.

NOTE ON THE EXPLOSION OF A SAW-MILL BOILER.

(EXTRACT FROM THE REPORT OF THE INSPECTOR OF MINES, M. DE GROSSOUVRE.)

Note sur l'Explosion d'un Bouilleur dans une scierie à bois, à Vierzon (Che Annales des Mines, Sér. 8, *Tome IV.*, 1883, *pp.* 238–248.

This boiler was horizontal, 14 feet 6 inches by 3 feet diameter, and connected wi two lateral heaters, each 14 feet 6 inches by 2 feet, the pressure being 6 kilog., about 15 lbs. The cause of explosion is stated to be inferior or brittle plates, and t Central Commission has issued the following notice:—

"The boiler explosion of 29th December, 1882, at Vierzon, is attributable in a gre measure to the inferior quality of the plates—very brittle and short in nature. T Government Inspector having only been informed of the accident some months aft its occurrence, cannot produce the accessory causes.

"A notice should be inserted in the *Annales des Mines*, as an extract from Grossouvre's report, with special reference to tests on iron boiler plates to be made the makers' works."

As no loss of life occurred many details are omitted in the report, but a very co plete table of the comparative tenacity and elasticity is incorporated, from which it concluded that the quality of the iron had sensibly deteriorated owing to undue stra on the elasticity of the plates. D. P. M.

NOTE ON THE EXPLOSION OF A VERTICAL BOILER AT MARNAVAL IRON WORKS.

(Extract from the Report of M. Trautmann, Chief Engineer.)

Note sur l'Explosion d'une Chaudière Verticale aux forges de Marnaval (Haute-Marne). Annales des Mines, Sér. 8, Tome IV., 1883, *pp.* 249-268.

This explosion (31st March, 1883) was very disastrous, occurring at the time (8 a.m.) when fully one hundred men were waiting for their daily start of work. Of these 28 were killed and 65 injured, many severely. The position of the boilers, of which there were seventeen, and of the rolling mills and other plant, is described, and the details of construction given (see Plate VII.)

The explosion appears to have resulted from inherent defects in the boiler itself, which, when erected, was purchased second-hand, and subsequently heightened. There were no indications of shortness of water, and no abnormal pressure could have taken place, as all the boilers were directly connected.

The Central Commission recommend the report of M. Trautmann to be published and circulated in works and manufactories, so as to direct general attention to the points he so carefully investigates. D. P. M.

ELECTRIC MACHINERY IN MINES.

Die Elektrische Kraftübertragung mit besondere Rücksicht auf Bergwerkszwecke. F. Poech. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 174–176 (*conclusion from p.* 163).

In the Thibaut shaft of the Société Anonyme de Saint-Étienne an electric winding engine is at work, drawing from 20 to 25 tons in ten minutes up a 13 fathom shaft. A gramme generator at bank is driven, at 20 to 1, by a small horizontal engine of 5 I.H.P., the power being transmitted by belting.

From the generator two wires are led to a gramme receiver, which is fixed at the bottom of the shaft and geared to the winding drum at 250 to 1.

Of the power indicated by the steam engine, 15 per cent. is absorbed by its own friction, and 50 per cent. by the electric machinery, the useful effect of the whole installation being 25 per cent.

The cost is as follows:—

	£	s.	d.
Steam engine	52	14	0
Pipes, straps, etc.	19	4	0
Seatings and mountings	9	12	0
Two Gramme machines, A type	143	15	0
Winding machinery in the pit	76	13	0
Foundations	12	0	0
Conducting wires (1,640 feet)	28	15	0
Total	£342	13	0

At the Jabin shaft at St. Étienne powerful electro-magnets are in use for opening the safety lamps. The oil can is screwed on to the protecting cylinder and fixed by two steel pins, which can only be drawn out by the magnets. The polarization of the magnets is affected by means of a Gramme machine worked with a treadle.

A. R. L.

TWO NEW IRON-SMELTING PROCESSES.

Zwei neuere Processe der Eisen-Erzeugung. PROF. JOSEF V. EHRENWERTH. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 190–193 *and* 209–210; *one Plate.*

I.—MR. H. C. BULL'S PROCESS.

Mr. Bull's process of iron-smelting differs from the usual methods in the employment of gases at very high temperatures to supersede the use of coal in the blast furnace, except in so far as it may be introduced as a carbonizing agent. The plant consists of an ordinary blast furnace with a chamber on the top for warming the charge, four large regenerative furnaces for heating the blast air, and two sets of apparatus for obtaining hydrogen gas from steam and raising it to the 1,112° Fahrenheit, at which it enters the blast furnace.

The four regenerative furnaces each consist of a vertical cylinder containing successive tiers of fire-brick gratings, from the bottom to near the top, where the combustion chamber is situated. The hot gases issuing from the top of the blast furnace are collected and led into the combustion chambers before mentioned, and, together with a certain quantity of cold air let in from the top, are burned and stream down to the bottom, where an outlet leads to the chimney. The furnaces being sufficiently heated, the gas inlets and outlet are closed, and cold air is introduced at the bottom and rises to an outlet valve at the top, whence it is led through pipes to the lower part of the blast furnace.

The hydrogen generators, of which there are two sets, each consist of several pairs, there being in this case four. Each pair consists of two small cylindrical furnaces with connection at the top, the one, which is the generator proper, shaped like a blast furnace, for burning coal or coke, and the other like a regenerative furnace, with successive tiers of fire-brick grating for superheating the steam.

The generator is charged from the top and fed through an opening in the bottom with hot air from the large regenerative furnaces.

The superheater is first heated with the gases from the generator, and, the outlet being then closed, steam is let in at the bottom and streams up to the top, whence it passes through the burning coals in the generator, and the resulting hydrogen passes through an outlet at the bottom and is led to the bottom of the blast furnace.

The advantages of this process are, that the heat in the furnace is not lowered by the admission of cold fuel; that the proportion of carbon in the iron admits of very easy regulation; and that the best qualities of iron or steel can be produced from very inferior ore at a minimum of cost, which is reckoned at about 30s. per ton. Tables are given of results obtained by the John Cockerill Company.

II.—M. LAURENT CELY'S PROCESS.

This process is based on the results of a series of experiments in the laboratory on impure iron under the influence of hydrogen gas. When the iron was raised to a high temperature and then subjected to the action of wet hydrogen, it was found that the metalloids which it contained, viz., sulphur, phosphorus, silicon, arsenic, carbon, nitrogen, etc., were released and passed off in the form of gas, leaving the iron as pure and homogeneous as that made from the best ores. When dry hydrogen was used, only the carbon was released.

The action on the carbon was somewhat different from that on the other metalloids, a part of it being carried off in the form of carburetted hydrogen, and the rest being left behind, but so distributed through the mass of metal as to give it a high degree of homogeneity.

To prove the feasibility of the process, four experimental furnaces have been erected in the neighbourhood of Paris, capable of dealing with about a ton of pig iron at a time.

The furnaces being charged and heated to a dull red heat, the air is expelled by means of a stream of carbonic acid, in order to prevent explosion, and the liquid re-agent, into which the exhaust pipe discharges, even at this stage shows signs of released impurities. When every particle of air has been expelled, the same small pipe admits a stream of hydrogen, a comparatively small quantity being found sufficient. As soon as the effect on the liquid re-agent is reduced to the formation of a slight sediment, the operation may be considered finished; the hydrogen is then expelled from the furnace by a stream of carbonic acid, as in the case of the air, and the furnace may be opened without danger. The hydrogen is obtained in a special apparatus of small size by the decomposition of zinc by means of diluted sulphuric acid, and passes through several purifiers before reaching the furnaces. Experiments with malleable cast iron, steel of inferior quality, and soft iron, resulted in the production of very good steel. The cost of the process, as applied to metals containing considerable impurities, proves to be, at the very outside, about 9½d. per ton. A. R. L.

AUSTRIAN MINING INDUSTRY IN THE YEAR 1881.

Der Bergwerksbetrieb in Oesterreich im Jahre, 1881 (*schluss*). Z. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 180–182.

In the year 1881 there were 791 mines, employing 85,492 persons, and 119 founding and smelting works, employing 10,170 persons, at work in Austria. Of the total 95,662 thus employed, 87,002 were men, 6,006 were women, and 2,654 were children, this being an increase of 1·05 per cent. on the previous year.

These were distributed as follows:—

In coal mines	37,113
„ brown coal mines	29,083
„ silver mines	5,623
„ ironstone mines	4,510
„ lead mines	3,325
„ zinc mines	1,682
„ graphite mines	991
„ copper mines...	708
„ sulphur and alum slate mines	627
„ quicksilver mines	585
„ other mines	1,245
„ ironworks	8,105
„ other works of various kinds	2,065
Total	95,662

In smelting works, etc., there were 6 deaths and 11 other accidents. As regards the mines, an average of 53,650 tons per death, and 21,950 tons per accident, was produced in 1880, and of 48,510 tons per death, and 21,840 tons per accident, in 1881. 167 deaths occurred and 204 serious accidents, representing 2·1 and 2·6 per thousand respectively.

A. R. L.

EXPERIMENTS WITH THE JAROLIMEK HAND BORING MACHINE.

Ueber den Kraftbedarf der Hand-Drehbohrmaschine von E. Jarolimek. HUGO PREUSS. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 187–190, 203–206, *and* 218–220; *one Plate.*

The hand machines experimented upon worked at a leverage of 9 to 1, the borers being from $1\frac{9}{16}$ inch to $1\frac{7}{8}$ inch diameter. In addition to these, experiments were made with similar machines worked by hydraulic power with diameters of borer of from 2 inches to $2\frac{5}{8}$ inches, and with a special experimental borer of $4\frac{7}{8}$ inches.

The experiments were conducted near the Layer shaft, at Raibl, in close-grained white-veined dolomite. The power was measured by means of a crank-dynamometer, the crank, when turned, acting upon a spring to which a pencil was attached, and so arranged that the work done was graphically represented by diagrams.

It is considered that a man can exert a power on the machine of about 120 foot pounds per second, and the borers are adjusted to suit this motive power.

According to a table of results obtained with borers of different sizes, a $1\frac{1}{8}$ inch borer gave a 44 per cent. better result, and a $1\frac{7}{8}$ inch borer a 70 per cent. better result than one of $1\frac{9}{16}$ inch, while a still larger borer of $2\frac{9}{16}$ inches diameter showed a result only 30 per cent. better than the one of $1\frac{9}{16}$ inch, the same motive power being employed throughout.

As a test under the conditions of actual work, a passage was driven 6 feet $6\frac{3}{4}$ inches high by 4 feet 11 inches broad and 51 feet 6 inches long, with a hand boring machine worked by two good hewers, the whole being accomplished in 20 shifts of 12 hours each. 54 holes were bored, of a total length of 162 feet, in 82 hours, a further time of 53 hours being spent in fixing the machine and firing shots. The passage was driven in 14 lengths, which were finished by hand work as successive groups of shots were fired.

The cost was 14s. per yard, and out of this the hewers received 3s. $10\frac{1}{2}$d. per shift. The best result of hand hewing, which had previously been accomplished in the mine, was the driving of a 52 feet 6 inches passage in 65·3 shifts of 12 hours each, at a cost of 16s. 8d. per yard, the hewers receiving 2s. 10d. per shift. A comparison between these results shows an advantage in favour of the machine of 60 per cent. in the amount of work done in a given time, and of 15 per cent. in the cost of the work, notwithstanding the fact that the workmen received 36 per cent. more wages per shift.

Boring experiments were also made with mixtures of Roman cement, Portland cement, sandstone, etc., and tables are given of results obtained with dolomite and with Roman cement. A. R. L.

EXPLOSIONS IN PRUSSIAN MINES.

Ueber die bisherige Thätigkeit der preussischen Schlagwetter-Commission. BERGRATH HASSLACHER. *Vereins-Mittheilungen, Beilage zur Oesterreichischen Zeitschrift für Berg- und Hüttenwesen*, 1883, *p.* 96.

Between the years 1861 and 1881 there were 1,350 explosions in Prussian mines, there having been relatively many fewer than in England. Two-thirds of these were traced to the lights used, the safety-lamp failing to afford protection in about one-fifth of the number of cases. Only one-eighth resulted from blasting. During the same period there were also 49 deaths by suffocation.

Two-thirds of the pits contain inflammable gas, from 9 to 10 per cent. having natural ventilation, and 82 per cent. being ventilated by furnaces, fans, etc.

One per cent. of the coals reach the surface by day drifts, and the rest are drawn by shafts. A. R. L.

HAULAGE AT THE ROTHSCHILD COLLIERY IN HRUSCHAU.

Seilförderung am Idaschachte der Freiherr von Rothschild'schen Steinkohlengrube in Hruschau. JOSEF BÖHM. *Vereins-Mittheilungen, Beilage zur Oesterreichischen Zeitschrift für Berg- und Hüttenwesen,* 1883, *pp.* 61–62.

The hauling distance is about 612 yards, the gradients varying from 0° to 12°, and the work is done by a double air engine, two hauling ropes, and one tail rope. This last, drawing a weighted tub, is rendered necessary by a bend in the way of about 360 yards, in wake of a trouble. A set, consisting of four full tubs, is coupled and drawn in eight minutes, four empty tubs going in-bye while the full ones are coming out. A tub holds about 14¾ cwts. The air engine, which is fitted with link reversing gear, has a diameter of cylinder of 8⅝ inches, with 11¾ inches stroke, and is geared to the drum at 2 to 5. The diameter of the drum is 3 feet 7¼ inches, the rope being wound on to it in five plies.

The compressed air at five atmospheres is supplied by a Stanek wet compressor, with 18¾ inches diameter of plunger and 31 inches stroke, working at 30 revolutions per minute. The air is stored in three reservoirs at bank, and led thence a distance of 100 fathoms, through 4-inch pipes, to a small reservoir beside the engine at the bottom of the shaft. The total capacity of the reservoirs and pipes is 1,024 cubic feet. The efficiency of the air delivery is 94 per cent., and of the compressing machinery 72 per cent. Owing to bends and differences of gradient in the way, the efficiency of the hauling machinery is low, and varies from 36·6 to 42·9 per cent., the corresponding amount of air used being from 2,457 cubic feet to 2,866 cubic feet of atmospheric air. The men required are one brakesman and four onsetters. The total cost of working and keeping in repair, including depreciation, amounts to 4¼d. per ton of coal drawn, and of this amount 2¾d. is due to the machinery. A. R. L.

THE ARLBERG TUNNEL BORED THROUGH.

Der Stollendurchschlag im Arlbergtunnel. Vereins-Mittheilungen, Beilage zur Oesterreichischen Zeitschrift für Berg- und Hüttenwesen, 1883, *pp.* 105–106.

On December 13th, 1883, a shot fired by one of the boring parties in this tunnel unexpectedly opened communication with those working from the opposite side, by blowing out a hole at the farther end.

The thickness of the dividing mass of rock, which from the measurements both parties had believed to be from 9 to 10 yards, proved to be only 2 yards.

In direction, the borings were extremely correct, the difference in the levels being almost *nil*, and that in the horizontal direction being barely 8 inches.

In driving the Mont-Cenis and St. Gothard tunnels, similar discrepancies occurred between the lengths computed by triangulation and those actually measured, the errors being on the same side. A. R. L.

MODIFICATIONS OF THE BESSEMER PROCESS.

Lecture by HOFFRATH V. TUNNER. *Vereins Mittheilungen, Beilage zur Oesterreichischen Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 99–101.

The most important of these has been in use at Avesta, in Sweden, since the year 1877. There are two single charcoal furnaces, each possessing its own movable converter, but, as a rule, only one is at work. A spare converter is kept in reserve. The charges are from 10 to 16 cwts., and an average of 30 charges is reckoned per day of 24 hours, or 95 tons per week of 5 days. From 87 to 88 per cent. of the raw iron is reproduced in the shape of ingots. The cost of Bessemer plant for one furnace, exclusive of the blast, is from £480 to £570.

The second method is one patented by Vogel and Nuth. The converter in this case is fixed and so arranged as not to require a separate blast. As in the former case, the charges are small, and it is claimed that a very high quality of steel is produced.

The third method touched upon is "The Chapin Pneumatic Process of Making Wrought Iron." The converter in this case is movable, but delivers the metal while still in a fluid state into a rotary puddling furnace, similar to that of Danks. The iron produced is of excellent quality, and the cost of production is less than by the ordinary methods of puddling. By the iron being first put through the converter less puddling is required in the rotary furnace, and the fettling of iron ore stands considerably better.

A. R. L.

THE BLEIBERG LEAD MINES.

Orientirender Vortrag über Bleiberg. E. MAKUC. *Vereins-Mittheilungen, Beilage zur Oesterreichischen Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 86–89.

Bleiberg lies in a valley of volcanic origin, and the lead ore occurs principally in the Hallstädter chalk formation, but is also found amongst slate and bituminous dolomite. The beds, which are very irregular, appear to have been formed by the filling up of previously existing caverns, which, though generally within the limits of one stratum, sometimes extend into others. The mass of deposit contained in one of these caverns shows a concentric texture, different mineral layers following each other in regular succession. The walls have first a coating of blende, and this is followed by sulphate of baryta, galena, marcasite, dolomite, and fluor. In some cases the mass of deposit so formed has been subsequently broken, and the resulting fissures have in their turn been filled, and can be traced in similar formations containing white and yellow lead ore, ead vitriol, plumbocalcit, flint zinc spar, coal zinc spar, zinc bloom, anhydrit, gypsum, brown ironstone, greenockit, loam and ochreous clay.

Some particulars are given of the smelting process, and a historical sketch of the district.

About 1,100 men are employed and 600 women, and the output of lead is from 4,000 to 5,000 tons a year.

A. R. L.

Verdampfungsversuche mit den Dampfkesseln der Seite 261 *besprochenen Zweicylindermaschine der Kammgarn Spinnerei Augsburg.* PROF. R. R. WERNER, *Darmstadt. Zeitschrift des Vereines Deutscher Ingenieure*, 1883, *pp.* 394–398.

A series of experiments, extending over five days, was made at Augsburg, in April, 1880, on two boilers of a spinning manufactory, to determine their efficiency. Each boiler had two flue tubes, in which lay the grate, having 21 square feet of area. The heating surface of each boiler was 624·32 square feet, and that of the feed water heater 312·16 square feet. The boilers had been cleaned some weeks before the trials. A table is given of the results obtained on two different days, viz., April 7th and April 8th, with different kinds of coal, giving the following analyses:—

	April 7th. Per Cent.	April 8th. Per Cent.
Carbon	70·89	46·92
Hydrogen	5·06	3·53
Oxygen and sulphur	12·14	15·16
Water	4·5	12·46
Ash	7·41	21·93

Theoretically, the first of these should contain 13,000 heat units and the second 8,700 heat units per pound. Of the total heating power thus employed there was absorbed:—

	April 7th. Per Cent.	April 8th. Per Cent.
In evaporating water	71·4	59·8
By loss through grate and chimney	16·3	32·0
Through imperfect combustion ...	5·7	3·0
Through radiation	6·6	5·2

Table of performance:—

	April 7th.	April 8th.
Number of boilers	1	2
Quality of coal	Good.	Inferior.
Coal per hour in pounds	244·5	457·68
Grate area in square feet	21	reduced to 29
Coal per square foot of grate per hour	11·18 lbs.	15·74 lbs.
Heating surface in boiler in square feet	624·32	1,248·6
Ditto in feed water heater „	312·16	624·3
Coal per square foot of heating surface of boiler	·3925 lbs.	·3725 lbs.
Water evaporated per hour...	1,989·9 lbs.	1,951·75 lbs.
One pound of coal evaporated	8·14 lbs.	4·26 lbs. water.
Temperature of boiler-house	75° F.	70° F.
Ditto of flue gases entering the chimney... ...	362°	360°
Ditto of flue gases above grate, as calculated ...	2,660°	1.240°
Ditto of water when entering the boiler	200°	273°

In calculating the amount of heat communicated to the water by one square foot of boiler heating surface per 1° difference of temperature, it was found that this was greater when using the inferior coal, which was ascribed to the presence of a larger proportion of water in this coal. J. N.

HYDRAULIC MACHINES IN THE SAXON SILVER MINES.

Ueber die Entwickelung der Wassersäulen Maschinen und die Anlagen zur Vermehrung der Wasserkräfte im Freiberger Bergrevier. GUSTAV HAHN. *Zeitschrift des Vereines Deutscher Ingenieure,* 1883, *pp.* 378–383. *One Plate.*

The silver production of the Freiberg mines has been much facilitated by the extensive employment of cheap hydraulic machines for drawing and pumping purposes. The feed water for these machines is partly collected in reservoirs and partly taken from adjacent rivers; the conduits, which are about 94 miles in length, being partly used for carrying off the water raised from the mines. The first motors in use were water-wheels, which have been replaced since 1820 by hydraulic machines placed in the shaft. The feed water was at first regulated by cocks, latterly by pistons. The prototype of these machines may be considered to be one which was constructed in 1823, and which gave a performance = ·7. It worked with a head of water of 50 fathoms and had a diameter of cylinder of 18⅜ inches and a stroke of 8 feet 4¼ inches, the number of lifts per minute being 4. It had one feeding cylinder with one inlet, one outlet, and one reversing piston. In Plate XX. are shown three of the present pumping engines. Figs. 1–4 illustrate one constructed by the lecturer, Herr G. Hahn. It works with a head of water of 68 fathoms, and has a diameter of cylinder of 19¼ inches and a stroke of 78¾ inches, the number of lifts per minute being 4. The greatest speed of the water is 300 feet per minute, the pressure per square inch of plunger being 240 lbs., and the volume of the feed water per second is 8·38 cubic feet. The spear works two plungers, one of 18¼ inches diameter at a depth of 56 fathoms, and one of 5 inches diameter at 76 fathoms. The total weight of the gear is about 52 cwt. The feed is effected by three pistons working in one cylinder. The flow of the water is regulated by two cocks, one in the inlet and the other in the outlet pipe, in the latter of which there is also a throttle valve. These points require special attention in the design; for a carefully adjusted feed, combined with large sized piping, will prevent shocks and undue wear. The second machine (see Figs. 5–7) has one piston only for both inlet and outlet, and one reversing piston. It works at a speed of water of 330 feet per minute with the greatest smoothness. The diameter of the plunger is 18½ inches and its stroke 94½ inches, the number of lifts per minute being 4·6. The descending pipe gives a head of water of 30·6 fathoms. The third machine (see Fig. 8) has a leather-packed piston in lieu of the plunger, and in consequence of having to pump against a pressure, it is fitted with a hydraulic balance-cylinder. J. N.

THE IRONSTONE SERIES OF LORRAINE.

Le Minerai de Fer de Lorraine au point de vue stratigraphique et paléontologique. By — BLEICHER. *Bulletin Société Géologique de France, Sér.* 3, *Vol. XII., pp.* 46–107, *with four Tables and one Section in text.*

The ironstones of Lorraine occur at or about the junction of the Upper Liassic and Lower Oolitic rocks, and really form part of both divisions, the ironstone beds characterized by *Trigonia navis* belonging to the Lias, and those with *Ammonites Murchisonæ* to the Inferior Oolite. Of late years they have been largely worked in the Meurthe-et-Moselle Department, and the present paper is chiefly based on the new facts brought to light by these workings. At Esch, near Villerupt, the ironstone series is 43 metres thick. In the central region of the Nancy basin the following subdivisions are recognizable:—

b.—Inferior Oolite Limestones.

	Metres.
5.—Sandy, gravelly, and marly limestone only occasionally sufficiently ferruginous for working	0·10 to 0·85
4.—Sandy calcareous ironstone, usually red or yellow ...	1·50

a.—Upper Liassic Ironstones.

3.—Earthy and marly ironstone	1·50 to 3·00
2.—Friable, marly, or nodular ironstone, greyish black and much worked	3·00 to 10·53
1.—Sandy ferruginous marls	(?)

In the northern portion of the Nancy basin, though the same geological horiz are present, the ferruginous character is so slight as to render the beds unworkable iron, and the same may be said with regard to its southern portion.

In the Longwy basin the same series is again found, and is much worked.

After giving very full stratigraphical and palæontological descriptions of the b as they are exposed along an outcrop of 120 kilometres, the writer concludes that actual ironstone affects lenticular forms of various extent and thickness, and that th lenticular masses occur, within the limits above given, at several fossil horizons.

G. A. L.

IRON PRODUCTION IN RUSSIA.

Exposition Nationale de Moscou en 1882. *L'Industrie du Fer. By* G. de Cuyp *Revue Universelle des Mines, Sér.* 2, *Vol. XV., pp.* 56–79.

An account of the fluctuations in the production of iron in Russia from 1718 to t present time. The following table is given, showing (in metric tons) the position h in this respect by Russia compared with other countries in the years 1870 and 1880:

	1870.	1880.
England	6,000,000 ...	7,808,000
United States	1,998,000 ...	3,886,000
Germany	1,376,000 ...	2,720,000
France	1,168,000 ...	1,696,000
Belgium	560,000 ...	592,000
Austria	400,000 ...	440,000
Russia	348,000 ...	436,000
Sweden	288,000 ...	400,000

In 1880, 240,000 tons were imported into the country. The discovery of coal the Urals, where vast deposits of iron ore are lying unworked, does not promise to ad much to Russian total iron production, owing to the quantity of ash and sulphur whic it contains. It is otherwise with the Donetz district, where coal of good quality an easily-obtained ironstone occur together in large quantities.

A very brief statistical enumeration of the Russian iron and steel-works represente at the Moscow exhibition concludes the paper.

G. A. L.

COAL PLANTS AND COAL.

(1) *Végétaux fossiles dans la houille et le terrain houiller. By* M. FAYOL. *Comptes-Rendus mensuels, Société de l'Industrie minérale,* 1884, *pp.* 36–38. *Two Plates (Pl. V., VI.)*

Attention is called to the presence of well-defined vegetable tissues in certain bright lenticular portions of the coal of Commentry and Montvicq. These "organised nodules" (*lentilles organisées*) alternate with duller zones of coal, and are repeated several times in lumps from three to four inches in thickness. Punctate structure and striations are often well shown, even to the naked eye, and the cellular, fibrous, and other tissue are sufficiently preserved to show the plants to which they belong. So far as the author has studied them, the remains must be referred to forms of *calamodendron* and ferns.

(2) *Note pour servir à l'histoire de la formation de la houille. By* M. RENAULT. *Same publication, pp.* 38–40.

In this paper the preliminary results of a microscopic examination of the tissues mentioned in the foregoing one are described. The conclusions arrived at are:—(1) That in many cases coal can only be due to the transformation *in situ* of the constituents of plants; (2) that the wood as well as the bark has contributed to the making of the coal; (3) that in the process of change into coal the organic elements—cells, etc.—have decreased in size, in all their dimensions, in a regular and determinable ratio.

These two papers open out an almost untouched field in the investigation of the structure and origin of coal. G. A. L.

THE ENDLESS ROPE FOR UNLOADING BOATS.

Application de la corde sans fin au déchargement des bateaux. Par M. V. DUJARDIN. *Société des Ingénieurs sortis de l'école du Hainaut, Sér.* 2, *Tome XIII., pp.* 62–70. *Three folding Plates.*

This paper describes an arrangement for discharging and stacking coal under the following conditions, viz.:—

The depots were about 60 yards long by 10 yards wide, and placed with their long sides parallel to the canal, 10 yards beyond the towing path, which was 3 yards wide and might not be interfered with.

A wooden staging was built, 3 yards high, so as to clear the towing path, from the canal to the centre of a depot, and, branching right and left, was carried to the end of the depot. Upon this a tramway was laid, with the space between the rails left open. Upon the tramway a truck ran, hanging from which was a one-ton kibble. This truck also carried sundry drums, shown in detail in the plans, which were set in motion by means of a 10 horse-power stationary engine through the intervention of a leather driving belt.

The truck being placed over the boat to be unladen, the empty kibble is let down into the vessel, and a full one is attached to the rope. This is then wound up to the required height, and held there by a pawl. The truck is then attached to an endless rope, and run into the depot, when the full kibble is dropped and an empty one taken up in its place to be carried back again to the boat; and so on.

The cost, including depreciation and interest on capital, assuming a minimum of 25,000 tons unloaded and stacked per annum, is 3d. per ton, as against 5¾d. when carried by coal-heavers. J. H. M.

FRACTURE OF A BORING TOOL BY DYNAMITE.

Sondage de Witterthum : Rupture d'un trépan par la dynamite. Par M. Brunet. *Comptes-Rendus mensuels, Société de l'Industrie Minérale,* 1883, *pp.* 182–183. *One Plate.*

A borehole, twelve inches in diameter, put down at Witterthum, near Marquises, Belgium, was stopped at a depth of 300 fathoms through the trepan sticking. In attempting to draw it the rods were broken, and the trepan and five yards of steel rods were left at the bottom of the hole.

After several fruitless attempts to withdraw them the hole was about to be abandoned, when it occurred to M. Brunet to try to break up the tool with dynamite. This he succeeded in doing, the broken pieces were drawn with some difficulty, and the boring proceeded with. J. H. M.

PUMPING BY ELECTRICITY.

Note sur le transport de force par l'électricité de Sainte-Elisabeth à la pompe de la Sorme. Par M. Graillot. *Comptes-Rendus mensuels, Société de l'Industrie Minérale,* 1883, *pp.* 239, 240. *One Plate.*

The author describes the arrangements by means of which the surplus power of the engine of a ventilating machine, situated a long way off, was utilised for pumping water to some boilers and to a farm.

The distance of the engine from the pump was 775 metres, from the pump to the farm and boilers 290 metres, the head against which the water was pumped was 20 metres, and the quantity pumped 1½ litres per second (say about 850 yards, 320 yards 22 yards, and 20 gallons per minute respectively). J. H. M.

LIFE ASSURANCE.

Conférence sur l'assurance sur la vie. Faites à l'école des mines de Saint-Etienne, le 3 *décembre,* 1882. *Par* M. L. Badon-Pascal. *Comptes-Rendus mensuels, Société de l'Industrie Minérale,* 1883, *pp.* 21–31 *and* 47–57.

This paper is the address of M. Badon-Pascal to the old students of the School of Mines at St. Etienne. It is the outcome of a resolution made by M. Chalmeton, at the congress held at Alais that an address should be given each year to young mining engineers upon life assurance.

M. Badon-Pascal begins with a short *résumé*, pointing out the *rationale* of insurance—both life assurance and insurance against accidents—and its great importance to professional men. He then recommends a system, introduced by the Bessèges Coal Company, of insuring the lives of principal *employés*, the employer paying one-half of the premiums. The Bessèges Company insure their engineers for sums varying from 20,000 to 100,000 francs (£800 to £4,000), the premiums of course depending upon the age of the assured. No one is compelled to avail himself of this arrangement; but, on the other hand, the company consider that they are under no moral obligation to assist the widows and orphans of those who do not.

The Montrambert and Béraudière Coal Company have lately adopted the same system, and there seems to be a prospect of its becoming general, so that on an engineer leaving a colliery his policy of insurance will be continued by his new employers.

J. H. M

A MINER'S STRETCHER.

Appareil pour le transport des blessés dans les Mines. Par LE DOCTEUR DUJOL. *Comptes-Rendus mensuels, Société de l'Industrie Minerale,* 1883, *pp.* 244-246. *One Plate.*

Doctor Dujol's stretcher is in three parts, hinged together, and forms a couch 6 feet long, by 20 inches wide, and 15 inches high; or a chair, the back and leg rest of which can be set at any angle. It is specially designed for use underground, and is provided with straps and padded partitions, so that the limbs, etc., may be firmly secured and further injury prevented during transit through the workings and up the shaft.

Many of the members of the Society of Mineral Industry present at the meeting thought that the stretcher could be easily carried about a mine, and suggested that it be made capable of being attached to a tram, with which modification they considered it would be very useful.

The details of its construction can be easily followed from the plan.

J. H. M.

TRANSMISSION OF POWER BY ELECTRICITY AT PÉRONNIÈRE* COLLIERY.

Transmission électrique des mines de la Péronnière. Par M. CHAROUSSET. *Comptes-Rendus mensuels, Société de l'Industrie Minérale,* 1883, *pp.* 5-10.

M. Charousset first describes some alterations that have been made in the machinery, and then shows by means of two tables the results of some experiments undertaken for the purpose of determining the passive resistances and the percentage of useful work obtained in different circumstances.

The distance the current is carried is, in one case, 1,330 yards to a staple, up which coals are drawn; and in the other, 1,650 yards, to a gin bank.

The useful effect was 30 per cent., with 1,280 revolutions per minute of the generating dynamo. But a higher efficiency could have been obtained with a greater number of revolutions. J. H. M.

THE DEVELOPMENT OF RAILWAYS.

Revue économique et statistique. Par M. PAUL TRASENSTER. *Le développement des chemins de fer. Revue Universelle des Mines, Sér.* 2, *Tome XII., pp.* 220-248.

In this paper (twenty-nine pages of small print, including two tables), the author gives the lengths of railway open in each country of the world at the end of each five years from 1840 to 1870, and at the end of each year from 1870 to 1881. He shows the increase for each period of ten years from 1840 to 1880, and for each year from 1870 to 1881; and tries to deduce, from what has occurred in the past, what may be anticipated for the immediate future.

As the paper consists almost entirely of figures a reference to it is perhaps sufficient. Taking the kilometer equal to five-eighths of a mile, we find that at the end of 1881 there were 249,586 miles (399,338 kilometers) of railway open throughout the world, and that the present rate of increase is about 16,000 miles per annum. J. H. M.

* See Trans. N.E.I., Vol. XXXII., Abs. p. 14.

AN ENDLESS CHAIN BANK AT MARIEMONT.

Charbonnage de Mariemont. Puits Saint-Abel. Description d'une application de trainage Mécanique Souterraine. Par M. Jos. Wuillot. *Société des Ingénieurs sortis de l'École du Hainaut, Sér. 2, Tome XIII., pp.* 103–107. *One folding Plate.*

The author describes an endless chain underground engine plane, in which the force derived from a falling gradient upon one part of the plane is utilized for hauling the coals up a rising gradient upon another part. The details of the arrangement are shown in the plate. J. H. M.

MINERAL STATISTICS.

Revue Économique et Statistique. Par M. Paul Trasenster. *Statistique Minérale. Revue Universelle des Mines, Sér.* 2, *Tome XIII., pp.* 466–481.

The Coal Trade.—Drawings in Millions of Metric Tons.

	1860.	1870.	1873.	1879.	1880.	1881.	1882.
Great Britain	85·4	112·2	129·0	135·8	149·3	156·6	158·8
United States	15·2	30·7	51·3	63·8	70·3	77·3	88·1
Germany	12·3	34·0	46·1	53·6	59·2	61·5	65·4
France	8·3	13·1	17·5	17·1	19·4	19·9	20·8
Belgium	9·6	13·7	15·8	15·4	16·9	16·9	17·5
Austro-Hungary ...	3·5	8·3	11·9	14·9	16·0	17·3	18·0 (?)
Russia	...	..	...	...	...	3·24	3·24 (?)
Spain	...	...	...	...	...	1·17	1·17 (?)
Sweden	...	...	...	...	...	0·12	0·12 (?)
Australia	...	...	...	...	...	2·20	2·20 (?)
Canada	...	...	...	...	...	1·437	1·437 (?)
India	...	...	...	...	1·03	1·03 (?)	1·03 (?)
Chili	...	...	...	...	...	0·80 (?)	0·80 (?)
Japan	...	...	...	...	0·53	0·53 (?)	0·53 (?)
China	...	...	...	...	...	3·00	3·00 (?)
Other countries ...	...	...	...	...	...	...	2·873 (?)
Total	134·3	212·0	271·6	300·5	332·66	363·027	385·0

The paper gives also the consumption per head in some of the more important countries, and the production per man employed.

The Iron and Steel Trade.—Production of Iron Ore in Millions of Metric Tons.

England	17·0
United States	10·0
Germany and Luxembourg	8·3
Spain	5·0
France	3·0 to 3·5
Other countries	4·2
Total	47·5

The paper also contains the production of cast iron, wrought iron, and steel, and the exportation and consumption of the same in the principal countries of the world.

THE ZINC, LEAD, COPPER, AND TIN TRADES.

The author gives the like statistics for these also, from which we find that Belgium produces the greatest quantity of zinc, England coming second; Spain the most lead, England standing second; England the most copper; Detroit the most tin, Cornwall standing next. J. H. M.

DRAWINGS AND LITHOGRAPHS OF FOSSILS.

Reproduction Autographique des Empreintes. Par M. CHANSELLE *et* M. FAYOL. *Comptes-Rendus mensuels, Société de l'Industrie Minérale,* 1883, *pp.* 36 *and* 119.

The impressions are taken as follows:—Printing ink is spread over the fossil by means of a roller, and ordinary white paper is damped and gently pressed upon it with the fingers. If a lithograph is required, autographic paper must be used.

As most coal-measure fossils would be damaged by printing ink, they should first be covered with silicate of potash, dried, and then inked as above. After the print has been taken every trace of the ink can be removed from them by washing in spirits (*en lavant à l'essence*).

Several lithographic plates taken by this method were exhibited to the members.

J. H. M.

THE ANTHRACITE AND LIME INDUSTRIES OF MAURIENNE.

Note sur les Anthracites et les Chaux de la Maurienne (Savoie). Par M. VILLET. *Bulletin de la Société de l'Industrie Minérale, Sér.* 2, *Tome XII., pp.* 5–42. *Two folding Plates.*

The author first describes the topography of Maurienne, illustrated by a geological map on a scale of $\frac{1}{250,000}$ (four miles to the inch) and two sections; and gives an account of its mineral resources, viz., its slate, limestone, gypsum, anthracite, spathic iron ore, argentiferous lead and copper. He then describes the anthracite mines and hydraulic limestone quarries in detail.

The point perhaps of most interest to the members of the North of England Institute is his description of the above-ground haulage by means of suspended railways or suspended inclined planes. This system was adopted because the mountainous nature of the country would have made ordinary railways very expensive to construct, and, even if made, the snow would have rendered them useless during a great part of the year.

Two iron wire ropes about four inches in circumference are stretched from point to point, as much as 700 yards being included in one span. An iron stirrup furnished with wheels runs upon each rope, and the tub is hung from the stirrup. In order to save weight the tub is made detachable from the wheels upon which it runs in the mine. These stretched ropes then take the place of the rails on an ordinary plane, and the sets, or single tubs, as the case may be, are hauled up and down by stationary engines, or are arranged to work like self-acting inclines as the gradients suit. The weight of tub varies from 8 to 10 cwts.

The first cost of a suspended railway to run 15 tons per day in 75 journeys, assuming a single span of 600 metres, with 300 metres difference of level, and two iron wire ropes 0·022 metres diameter (say a 2½ inch rope), would be 5,415·45 francs (£216). The iron cables last about six years. J. H. M.

THE SCHOOL OF MINES, LIÉGE.—EXTRACT FROM THE REPORT OF M. TRASENSTER.

Bulletin de l'Association des Ingénieurs sortis de l'École de Liége, Nouvelle Série, Tome VII., pp. 223–238.

During the session 1882–83 the names of 1,314 students were on the books, being 111 more than the preceding year. 37* sat at the final examination, all of whom obtained diplomas, 21 as mining engineers, 2 as engineers of arts and manufactures, and 4 as mechanical engineers.

An Electro-Technical Institute is about to be added to the school at a cost of 100,000 francs (£4,000), presented by M. Montéfiore, M.P., and an old student; and the degree of engineer-electrician has been created by the Government to be awarded—

1.—To men holding the degree of mining or mechanical engineer (Belgian Section), after one year's special training on certain subjects, the programme of which is given.

2.—To students of mining and mechanical engineering (Belgian Section) who have passed through their preparatory courses, after two years' special study, the programme of which is given.

3.—Certificates will be given to engineers of arts and manufactures and to mechanical engineers (Foreign Section), after a special course of one year.

J. H. M.

OBSERVATIONS ON UNDERGROUND WATER.

Die Erscheinungsformen des Grundwassers. O. Smreker. *Zeitschrift des Vereins Deutscher Ingenieure,* 1883, *pp.* 681–691. *Illustrated in the text.*

The lecturer mentions two theories accounting for the existence of underground water. According to one of these the moisture of the atmosphere, when precipitating, partly trickles through the soil into the lower strata of the earth. The theory of Dr. Vogler maintains that this water cannot trickle through to any considerable depth, but that the atmosphere itself impregnates the ground, and coming into contact with the deeper and colder strata condenses and forms the underground water directly. This water, like that at the surface, exists in the shape of brooks, streams, and large expanses, which, according to the inclination of their beds, will either be still or flowing. This is ascertained by sounding in a number of boreholes, the direction of the flow being determined by putting colouring matter or a salt in the water of one hole, and observing in which of the other holes the water is affected by it. The underground water rises and falls like the surface water, but more slowly. As a rule, the beds of rivers and lakes allow of no connexion between the respective levels of the water above and below ground. A striking illustration of this was given in the case of the River Letta, near Bologna, where the level of the underground water was found to be 5 feet below that of the river, and this difference was increased on both sides of the river to 8 feet 10½ inches by pumping from one borehole.

The underground water is met with in natural springs, artesian and ordinary wells. Hydrological experiments carried on in the Bohemian Lowlands, while seeking water for the city of Prague, showed the underground connexion existing between different

* 27?—Sub-Editor.

springs. The surface there consists of sandstone, resting partly on a bed of marl. A plan and section of the Kokerin valley are given in the text. Two brooks meet near a village, and between their banks are numerous small springs. In the village are seven wells, and between it and the nearest brook is a very large spring. The observations were carried on during the winter of 1880, when the two brooks were dammed up to ascertain the amount of water which they take in from these sources. The water in the nearer wells and in the large spring rose 10 inches, that in the wells farthest away only 5 inches. The soundings taken on December 30th gave a depth of water in the wells of 15 to 18 inches, showing also that the level of the underground water was 10¼ inches lower at the large spring. Four weeks after the dams had been removed the depth of water in the wells was from 9 to 15 inches. The level of the underground water shown in the section is in accordance with these soundings, the full line representing the natural one. The wells were dug a century ago, and their shallowness is a proof that the water level has not altered since that time, as its lowering would have necessitated deeper sinking, there being just water enough to allow the buckets to be filled. The soundings also show that the underground water flows from under the village towards the brooks, causing the rise of the large spring, and the smaller springs result from its breaking through rents in the clay. J. N.

IMPROVED GAS GENERATOR.

Verbesserter Gröbe-Lürmann Generator. FRITZ LÜRMANN. *Zeitscrift des Vereins Deutscher Ingenieure*, 1883, *pp.* 664-668. *Two Plates.*

The new Groebe-Lürmann Generator differs from the older one in having a row of coking holes on each side of the gas chamber, instead of only on one. These holes are built on a slope, and the coal as it is coked falls on to a grate at the bottom of the chamber and is gradually raked out, a certain quantity being always left. The air, rising through the coke on the grate, produces carbonic oxide gas, which is led by brick passages to the furnace which is to be heated. From here the burnt gases are led under the furnace where they heat the air required for the combustion, and round the gas chamber, whence after passing round the coking holes they reach the boilers and escape through the chimney.

The double arrangement of coking holes, besides requiring less gas chamber space, is more efficient in its working, as the coke on the grate is not so liable to get low, and the formation of carbonic acid instead of oxide is therefore less likely to result. In some cases the air, instead of passing through a grate, has been supplied by blast, and the gases are then passed through a purifier before reaching the furnace, to free them from dust. The gas may either pass first round the coking holes and then through the purifier, or it may go to the purifier first, so as to prevent the accumulation of dust in the brick passages.

When these generators are applied to blast furnaces, or to the production of heating gas for general household or industrial purposes, precaution must be taken to prevent their overheating. This is done by the injection of hot water or steam, which absorbs a portion of the superfluous heat, and passes with the gases into the furnace in the shape of carbonic oxide.

Gas generators with natural draught must be charged with non-caking coal; but for those with the blast a certain proportion of nuts of caking coal may be mixed.

J. N.

REFRIGERATING MACHINERY.

Die Wirkungsweise der Kaeltemaschinen. R. SCHÖTTLER. *Zeitschrift des Vereins Deutscher Ingenieure*, 1883, *pp.* 549–557. *Illustrated in the text.*

The author shows that, though in a steam engine efficiency increases with large variations of temperature, in engines for chilling air or vapour such variation should be as small as possible.

Most of the latter are open, and compress a fresh volume of air at each stroke. The engine of Bell and Coleman is referred to as that in most general use. The air is drawn into a cylinder where it is compressed and cooled by the injection of water-spray, and passed through the condenser, where it is further cooled and dried. It is then allowed to expand in a second cylinder, and finally exhausted into the chamber which is to be cooled. An insufficient drying of the air will cause ice or snow to form in the expansion cylinder, and lead to a rapid wear of its working parts.

In other refrigerators liquid ammonia is vaporized by being passed through coils of piping surrounded by the water to be cooled. The temperature in the condenser is usually 68° F.; that in the refrigerator 5° or less. To compare these two systems of refrigerating, the author calculates for each the work required to abstract 9,000 units of heat during an hour. The number of strokes is 100 per minute, the horse-power required being 8·1 for the air engine and 8·8 for the ammonia engine. The compression cylinder of the former has a volume of 21·34 cubic feet; the expansion cylinder 19·24 cubic feet; and 7·4 units of heat are abstracted from the air by the expenditure of one unit of working heat. Assuming the ammonia used to contain 10 per cent. of water, the volume of its single cylinder would be only 3·88 cubic feet, and the factor of efficiency 6·8. Although the vapour engines require additional apparatus when applied to air, they are preferred for that purpose to the compression engines, the latter being used with advantage for cooling meat or fish, which will keep better in cold air than on ice.

A second group of refrigerators is based on the reduction of heat which accompanies the absorption of ammonia vapour by water. These absorption engines were invented by Carré. The transmission of the vapour from the pump cylinder to the condenser is effected by a system of cooling tubes, the arrangement of which is illustrated by diagrams. They require about three and a half times as much water as the first-mentioned engines, and their efficiency is smaller. A combination of the two systems is the vacuum engine of Carré and Windhausen, which is based on the fact that in a vacuum, water may be converted into ice as long as its vapour is absorbed by sulphuric acid. The cooling water in the condenser is constantly being removed, and the vapour is partly removed by a powerful air-pump. J. N.

REGENERATORS FOR AIR ENGINES.

Ueber die Anwendung von Regeneratoren bei Heissluftmaschinen. M. SCHROETER. *Zeitschrift des Vereins Deutscher Ingenieure*, 1883, *pp.* 449–459.

The theory of the regenerator as applied to air engines is given at length, and the factor of efficiency calculated for an engine with and without a regenerator. The theoretical assumption that the changes of temperature in the regenerator correspond exactly with those of the air admitted and discharged is not borne out in practice, but a mean temperature is created after a certain time which renders the action imperfect. This is given as the principal reason why the regenerator fails in practice. In the case of an air engine constructed recently by J. Hock, in which the air is heated directly in the engine, a regenerator has been applied with advantage. Mention is made of the trials with regenerators made by C. W. Siemens, and published in Rankine's work on the steam engine. J. N.

AIR HEATERS FOR BLAST FURNACES.

Ueber Winderhitzer für Hochöfen. FRITZ LÜRMANN. *Zeitschrift des Vereins Deutscher Ingenieure*, 1883, *pp.* 475–485. *One Plate.*

Criticisms passed upon a former lecture of Herr Lürmann's led him to make enquiries among furnace managers about some of the points raised, the results of which he here communicates.

The waste gases from the blast furnace carry with them into the heating apparatus a good deal of dust, which accumulates there, and, being afterwards carried back into the furnace by the air, tends to reduce the efficiency of the blast. The quantity of dust thus carried varies with the velocity of the gases when leaving the furnace, this being the greater the more compact the charge and the smaller the pipes. One method of purifying the gases is to pass them through large chambers, so that their velocity is diminished and the dust settles down. In the case of two air heaters, built on this principle in France, the velocity is reduced from 21·5 feet per second to from 1·6 to 3·3 feet per second, one of the chambers being built over a stream of water which carries off the dust as it settles. Other expedients for getting rid of the dust are to pass the gases through loose heaps of bricks and brushwood, and to hang up sheets of iron vertically in the heater, the first of these means being found very effective.

Belani moistens the gases by water diffused as spray by a jet of steam, the dust being thus moistened and laid, and then passes them through a condenser to dry them.

It is stated that an annual saving of £3,000 has been effected in the working of a Silesian blast furnace by raising the temperature of the air admitted to the furnace from 800° to 1,300° F. This has been effected by the adoption of three Whitwell stoves, each 22 feet in diameter by 65 feet high, and having a heating area of 25,834 square feet, the cost of each stove being £1,750. An improvement on these stoves has been patented by Herr Goedecke, who, in order to introduce it, offers to apply his invention for two-thirds of its cost.

Figs. 1 and 2 (Plate XXII.) illustrate a Whitwell stove of the latest design, Figs. 3 and 4 showing an earlier construction. Figs. 5 and 6 represent a stove of the Cowper-Siemens system. In the latter it is stated to be a great objection that alternate tiers of brick grating are placed at right angles to each other, as they are thus much more likely to be choked by dust. M. Remaury publishes the following comparative table of the costs of the two systems, as experienced with stoves built and worked in the North of France:—

Name of Apparatus.	Diameter.	Height.	Number of Heaters for a production of 80 tons in 24 hours.				Heating Area.		Material per Heater.		Cost of the Finished Heaters.	
			For Gas.	For Wind.	Spare.	Total.	Per Heater	Total.	Iron.	Bricks.	For One Heater.	For the Whole Arrangt.
	Ft.	Ft.					Sq. Ft.	Sq. Ft.	Lbs.	Tons.	Francs.	Francs.
Whitwell, new system ...	22	56	2	1	0	3	25,188	50,376	123,459	708	2,157	6,471
Do., old system	22	28½	6	2	0	8	8,611	51,666	83,330	358	1,294	10,352
Cowper ...	21	56	2	1	1	4	25,403	50,806	136,686	669	2,118	8,472

According to M. Remaury the air heating area for blast furnaces varies with the local conditions of working and the nature of the charge; but in any case three Whitwell stoves are equivalent to four Cowper stoves, one of the latter being always out of

work for cleaning. The Whitwell stoves can be cleaned while working, and in them the segregation of dust is facilitated by the frequent reversal of the direction of the gases passing through them. A matter of importance in cleaning is the position of the bricks, stoves with tiers of flat bricks being least liable to shrink. A calculation is given of the heating area of a stove intended for a furnace dealing with 74 tons, in which 204 lbs. of carbon are oxidized per minute, the amount of air required for this being 30,700 cubic feet.

It is found that for lower temperatures of the air blast, say up to 1,100° F., the old cast iron air heaters are better than those of brick. J. N.

EXPERIMENTS WITH ELECTRIC AND GAS LIGHT IN A MUNICH THEATRE.

Beleuchtung des kgl. Residenz Theaters in München nach Edison's System. Bedeutung der electrischen Beleuchtung für die Gesundheitspflege und das Rettungswesen. Zeitschrift des Vereins Deutscher Ingenieure, 1883, *pp.* 508–510.

The light is supplied by three Edison dynamos, pattern K, each feeding 250 six-candle incandescent lamps. The dynamos are each driven by a compound engine of 40 horse-power, and run at 900 revolutions per minute. Shortly after leaving the dynamo the current is divided into two, one for 88 candles for the lobbies and staircases, and the other for 678 candles for the stage and auditory. The light of the lamps, although without glass globes, is stated to be more agreeable than gas light.

Experiments have been made to ascertain the relative effects of gas and electric light on the temperature, and the amount of carbonic acid in the theatre both empty and when occupied by from 500 to 600 persons. The temperature was noted every ten minutes. In the upper parts of the house when empty it was ten times as high with gas light as with electric light. During a performance by electric light the reading (73° F.) in the higher parts of the house was about the same as that taken in the pit when gaslight was used, notwithstanding that the temperature out of doors was higher in the first case. The greatest amount of carbonic acid in a full house was ·23 per cent. with gas and ·18 per cent. with electric light. J. N.

DIAMOND ROCK BORER FOR ARTESIAN WELLS.

Diamantbohrer für artesische Brunnen der American-Diamond-Rock-Boring-Comp. Bergrath Tecklenburg. *Zeitschrift des Vereins Deutscher Ingenieure,* 1883, *pp.* 517–518. *Illustrated in the text.*

The boring machine is fixed to a cast-iron framework, which carries an oscillating steam cylinder turning the spindle by means of spur and bevel wheels. A cross-bar is mounted on the top of the spindle, to which are attached the piston rods of two hydraulic cylinders. The drill is thus forced into the rock by hydraulic pressure, which is regulated by the supply of water from the accumulator. The spindle consists of tubes coupled by interior muffs, so that the borehole is round and smooth and ready to receive the pipes. The rinsing of the hole is effected by a separate pump delivering the water through the hollow spindle and the annular boring bit. The machine has been applied lately in Pennsylvania by the Wilkes Coal Company for boring three 9-inch holes, two of them being 59·4 fathoms and the other 50 fathoms deep.

J. N.

SUBSTITUTES FOR BLASTING IN COAL MINES.

Einiges über die Kohlengewinnung mit comprimirten Kalkpatronen und mit dem Levet'schen hydraulischen Abtriebkeil. J. MAYER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen,* 1883, *pp.* 367–370, 386–389, *and* 407–410. *Illustrated in the text.*

Two methods of bringing down the coal are here principally dealt with, viz., "the compressed lime process" and "the Levet hydraulic wedge."

There are few coal mines in Austria so gassy as to make blasting dangerous, and to most of the principal seams that are worked neither of these methods is quite suitable.

In the Polish Ostrau coal-field the seams are as follows:—

Name.	Thickness. Ft.	In.	Quality.
Thick Seam	13	1½ ...	Hard and tough and very gassy.
Juno do.	3	7 ...	Hard and gritty; kirving practised.
Urania do. 2 ft. 8 in. to	3	0 ...	Hard and gritty.
II. Lying Seam	4	11 ...	In some parts dirty; in others good and suitable for kirving.
IV. Do. do.	3	0 ...	Clean hard coal; suitable for curving.
V. Do. do.	3	3 ...	.....

In these seams the cost of the blasting powder used per ton of coal brought to bank is as follows:—

		s.	d.
Thick Seam	main way, Wilhelm Shaft	0	5¼
	do. Jacob Shaft	0	2⅞
	boards, Wilhelm Shaft	1	0¼
	do. Jacob Shaft	1	0½
Juno do.	do. do.	0	5¼
Urania do.	do. do.	0	5½
II. Lying Seam	do. do.	0	2½
IV. Do.	do. do.	0	3⅞
V. Do.	do. do.	0	5½

Large quantities of gas were met with in a passage in the Thick Seam near the Wilhelm Shaft, and recourse was had to the compressed lime process, the Levet hydraulic wedge being also tried in neighbouring boards.

The passage in question had previously been worked 7 feet 2½ inches broad by 6 feet 6¾ inches high, the practice being to kirve at half height and blast the top down with two charges of dynamite, the bottom being afterwards blasted up with two more charges.

The first attempts to bring down the top piece with lime were unsuccessful with two, three, and even four shots, and it was found necessary to nick the coal at both sides, after which one shot was found sufficient. The shot holes, kirving, and nicking were carried to the same depth, viz., about 40 inches.

A miner's wages were about 2s. 1¼d. per shift of eight hours, during which he could kirve nearly 13 square feet, or nick nearly 12 square feet of coal. The cost for kirving, nicking, and bringing down the upper coal was as follows:—

	s.	d.
Four shifts nicking and kirving, at 2s. 1¼d.	8	5
One shift boring and incidental work	2	1¼
	10	6¼
Lime cartridges (one hole)	0	7

In round numbers the total cost came to 11s. 2d. per 40 inches, or 10s. a yard.

The highest cost of working with dynamite was 6s. 1d. per yard, and in general the work cost upwards of 65 per cent. more with lime cartridges than with dynamite.

The cost of pure hand work per yard came to 11s., but the coals were won in much smaller lumps. The comparative results were :—

	Round Coals. Per Cent.	Nuts. Per Cent.	Small. Per Cent.
With lime blasting	30 ...	25 ...	45
With pure hand work	14 ...	25 ...	61

The difference in value of the coals thus won came to about 4d. per yard, which brought the comparative cost per yard of the hand work up to 11s. 4d.

The cost of the hand work thus came to 13 per cent. more than that done with the lime cartridges, and to 90 per cent. more than with dynamite.

The comparative costliness of the lime cartridge work was due to the badness of the roof, which limited the width of the passage, the process being most suitable to long-wall working.

An attempt made to work with a 13-feet board had to be abandoned because the roof would not stand without timbering.

Another attempt was made to work with the lime process in the Thick Seam with a face 19 feet 8 inches broad in the full height of 13 feet 1½ inches. The coal was kirved and brought down in successive juds from the bottom of from 2 feet 8 inches to 3 feet 11 inches thick, the cartridges failing to move more than this thickness. Three holes were required in the face breadth for each jud, those near the top of the seam being found very troublesome to bore. To prevent danger it was found necessary to shore up the higher juds until it was time to apply the cartridges. The process was thus found costly in this case also, but in trials in the thinner Juno, Urania, and V. Lying Seams it cost about the same as the ordinary method of blasting.

The Levet hydraulic wedge was tried in the gassy quarter near the Wilhelm Shaft under the same conditions as the lime process. The holes required for this are 2 feet 3½ inches deep by 3 inches in diameter. Two half-round steel cheeks project 1 foot 11 inches into the hole, each being tapered thin at the inner end. Outside is fixed a cylinder with a long piston rod projecting between the steel cheeks and attached to the point of an iron wedge, the butt of which is against the inner end of the hole. Water is introduced to the piston from a hand-pump underneath, and the wedge is gradually drawn out of the hole, opening the steel cheeks, and thereby causing a downward pressure tending to split off the jud.

The first cost of the machine was about £25.

The apparatus being used in the 7 feet board before mentioned, it was found necessary again to nick on both sides, so that the boring, kirving, and nicking were much the same as before, except that they only went to the depth of 2 feet 3½ inches. Owing to the hardness of the coal the steel cheeks frequently got bent, and the machine required constant repairs. A pair of thicker cheeks was obtained, but the cylinder ultimately burst.

The cost per yard came to 11s. 2d.

If applied to long-wall work the system would require a separate apparatus for each hole, the conditions being otherwise similar to those for the lime process. A calculation, based on the power which would be required to burst the cylinder, shows the force exerted by the wedge on the coal to be about 33 tons. A. R. L.

ROPE TRANSPORT IN SEAMS LYING AT HIGH ANGLES.

Bremsförderung in Aufbrüchen mit geringer steigung in Sillweg. WILHELM v. REUSZ. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 356, 357. *One Plate.*

Herr v. Reusz describes an arrangement for bringing out the coals from a board in seam rising at an angle of from 20° to 30°. A wire rope is stretched just below the roof between two upright posts, the one near the face and the other at the bottom of the board at the farther side of the main way. Below the rope is laid a small set of rails and two small tubs; the one hanging on the rope and the other running on the rails are connected with each other by a smaller rope passing round a sheave fixed in the upper post, so that when one is filled and allowed to descend to the tub on the main way, the other is drawn up to be filled again. At the bottom of the board the rails rise up to the height of the tops of the large tubs, so that the small tubs can be easily discharged. The upper post is moved farther on as the work proceeds. The wire rope passes through it, being jammed by a screw, and must be kept long enough to reach the top of the board, the loose end being coiled up until required. The rope is made taut by a stretching screw at the lower post. The loose end of the small running rope is coiled up on the end of one of the small tubs. The speed of travelling is regulated by a brake at the top.

As the distance between the posts increases it is necessary to support the wire rope at intervals, so that the two tubs may not foul each other. It is claimed that the arrangement has the effect of improving the ventilation, and an instance is given in which a board was driven for 110 yards in the middle of summer before the ventilation became bad. For the larger rope an old winding rope is found to answer well.

A. R. L.

REVOLVING SCREENS.

Der Klönne'sche Kreiselrätter. Oesterreichische Zeitschrift für Berg- und Hüttenwesen, 1883, *pp.* 210, 211.

Herr Klönne, manager of the Fortschritt Mine, near Dux, is the patentee of a new apparatus for screening coals, the novel feature of which is that the screens are set at small angles of inclination and made to revolve. These latter, five in number, are set in a box-shaped framework 6 feet 6 inches long by 3 feet 3 inches broad by 7 feet 6 inches high, and sloped alternately towards the front and towards the back. The motive power is communicated by a horizontal shaft and bevel wheels to a vertical spindle with a crank-shaped arm, which works in a socket at one side of the box, and is coupled to a similar arm and spindle on the other side. Each point in the box is thus made to move in a circle whose radius is the length of one of the arms.

The apparatus is supported by four stanchions with spherical heads arranged so as to give the effect of rolling on four balls.

The meshes of the successive tiers are 5½ inches, 2 inches, 1⅛ inches, ½ inch, and ¼ inch square respectively.

The screens work at the rate of 140 revolutions per minute, and can deal with from six to eight wagons of coals per hour, the indicated horse-power required to drive them being about 3½.

The special advantages of the system are that it causes very little damage to the coals, and that it delivers the different kinds exceptionally clean and free from dust.

A. R. L.

SINKING THROUGH WATER-BEARING STRATA.

H. Poetsch's Methode des Schachtabteufens im schwimmenden Gebirge. E. *Oesterreichische Zeitschrift für Berg- und Huttenwesen*, 1883, *p.* 396.

In the summer of 1883 the first practical attempt to sink a shaft by the Poetsch method was made in the Archibald Mine, near Schneidlingen, and brought to a successful issue.

The sinking is not described in detail, but the principle involved is that of freezing the water round the sides of the shaft, and keeping it back by a layer of ice.

The shaft had been sunk 18½ fathoms before water was met with, and the earth temperature of the watery stratum was then 52° F., that of the air at the bottom of the shaft being 53½° F. After six days' work with the freezing apparatus the earth temperature fell from 20° to 23° F., the temperature in the middle of the shaft being about 7° higher.

The shaft was then successfully sunk through the watery stratum, and mining engineers wishing to see the process at work were invited to communicate with Herr Poetsch. A. R. L.

THE JAROLIMEK HAND-BORING MACHINE.

Betriebs-Ergebnisse mit der E. Jarolimek'schen Hand-Drehbohrmaschine beim Querschlagsbetriebe in Kronprinz Rudolf-Stefanschächter Grubenbaue zu Bohutin bei Pribram. JOSEPH HOZÁK. *Oesterreichische Zeitschrift für Berg und Hüttenwesen*, 1883, *pp.* 381–384, 395–396, 411–412, 422–424, *and* 433–435.

At Bohutin, near Pribram, one of the above machines was obtained for experimental purposes in March 1882, and set to work in a drift through a granite dyke. The stone was at first rather broken and moderately soft, but in the interior of the dyke it became compact and hard.

A regular trial began on the following month, the drift being 5 feet 3 inches wide. At first the price paid was the same as for hand work, viz., 46s. per yard. In the softish stone first met with the machine bored about ·5 inch per minute, or ·1 inch per turn, the gearing being at 1 to 9, and the turns per minute 5. In the harder stone the advance per stone fell to ·045 inch. It was found desirable to use plenty of water, and the amount used rose in the harder stone to 1¼ gallons per minute.

One man worked the machine from eight to ten minutes at a time, making about 45 turns per minute. The boring tools required sharpening about every 30 inches in the softer stone, and about every 20 inches where it was hard.

The mode of working was to begin with from four to five machine boreholes from 27 to 43 inches deep, and shoot down a piece of the rock face from the middle of the passage, and to follow this up by hand-work, and trim down the remaining pieces with eight to ten hand boreholes of from 12 to 20 inches deep.

The machine borehole charges were fired together by electricity, the smaller charges being fired separately by the ordinary methods. The explosive used for the 2-inch machine holes was blasting gelatine made up in $1\frac{3}{16}$-inch cartridges; that for the 1-inch band holes being the much cheaper dynamite, No. 3, in ⅝-inch cartridges.

As to time, a group of four or five machine hole shots fired by electricity brought down 2 feet 7 inches of rock after about eight shifts' work, and the trimming up of the passage with eight to ten hand shots followed in about four more shifts. As a rule a machine hole charge took about 11 lbs. of blasting gelatine enclosed in a $1\frac{3}{16}$-inch case.

This work was continued for four months. Then followed one month of hand-work alone, one month more with machine and hand-work combined, and again another month of hand-work alone, the explosive used being blasting gelatine and dynamite No. 3 in each case. The same men were employed throughout, and at the same rate of pay, viz., 46s. per yard.

Tables of results are given which show that the distance driven was 13 feet per month by hand-work against 24 feet per month by hand and machine-work combined during the earlier months, and 21 feet 6 inches per month during the last month but one, which was entirely in the harder stone. Even in the latter case the result was thus 65 per cent. better by the combined method than by hand-work alone.

The cost of explosive materials per yard came to about 15s. for machine and hand-work against 13s. 7d. for hand-work alone. In the former case, though somewhat the higher, it only amounted to one-third of the wages of the workmen.

The experiment was tried of working entirely with the machine borer, but the expense of the blasting gelatine, which was then exclusively used, was found so great that the attempt was abandoned. The cost of explosive material would in this case have been nearly two and a half times as great as before. The expenses incurred for cost of tools, wear and tear, and other incidentals came to 24s. per yard with machine and hand-work, against 20s. 6d. per yard with hand-work alone.

The result then was that the work was done 70 per cent. more quickly by the help of the machine, and the workmen being paid in each case by the yard driven, the expenses were:—

Wages and tools	70s. 0d.	per yard	for machine	and hand-work.
Explosives	15s. 0d.	do.	do.	do.
Wages and tools	66s. 6d.	do.	hand-work alone.	
Explosives	13s. 7d.	do.	do.	

A. R. L.

CHARCOAL BLAST FURNACES.

Ueber Grösee, Windmenge und Temperatur mit Holzkohle gespeister Eisenhochöfen. P. Tunner. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen.* 1883, *pp.* 268–271.

While blast furnaces fed with coke or coal have recently undergone many improvements and been much increased in size, those fed with charcoal, except in some cases in America, have remained almost stationary. Herr Tunner contends that charcoal furnaces with some modifications, rendered necessary by the smaller specific gravity of the fuel, may be advantageously altered in the same direction.

From its lightness, charcoal is apt to lie on the top, while the heavier ore sinks to the bottom, and if the body of the furnace is made very wide this tendency is much increased.

Hence it is recommended that the body of the charcoal furnace be kept narrower in proportion, but that the width of the lower part and the height be increased to the dimensions usual in coal or coke furnaces turning out from 50 to 75 tons a day in all cases where the operations are large enough to keep several of the present furnaces in blast. Also, with regard to blast, it is considered that the prevailing prejudice against high temperatures is a mistaken one, and that the volume of air might with advantage be considerably increased. A. R. L.

METALLIC VEINS IN THE COAL-MEASURES OF UPPER SILESIA.

Ueber Erzgänge und Gangmineralien in dem Steinkohlengebirge Oberschlesiens. DR. BERNHARD KOSMANN. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 289-291 *and* 302-304.

The process of formation of the veins and pockets of metallic ore found in the Coal-Measures of the Silesian district, and also in the Mussel Limestone overlying them, presents a difficulty of which many solutions have been proposed. Dr. Kosmann considers that they have found their way in the form of mineral springs from the measures below into previously existing cracks and crevices in the strata. Examples are given of their occurrence in several different mines, and it is shown that they are generally found in the neighbourhood of troubles and such like dislocations of the strata; and that, whereas they do not as a rule penetrate through the limestone, they can always be traced to the strata below. A. R. L.

THE ELECTRIC LIGHT AT THE GRADENBERG WORKS.

Die elektrische Beleuchtung der Hütte Gradenberg bei Köflach. PROF. JOSEF V. EHRENWERTH. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen.* 1883, *pp.* 256, 257.

A part of the rolling mills of Messrs. H. & C. Mitsch, in Gradenberg, is lighted by four differential electric lamps of 350 candle-power each from the firm of Messrs. Siemens and Halske. The lights are required only in the winter time, when they are in use for four hours every evening.

The motive power is obtained from a water-wheel of 19 feet 9 inches diameter and 4 feet 11 inches in breadth, which is used during the day to drive one of the cutting machines. The first cost of the installation was about £230, the compressed coke-burners costing about 3d. a yard, and a piece 8 inches long lasting five hours.

The cost of the burners is found to be about equal to that of the oil and petroleum which were used previous to the electric installation. A. R. L.

DIFFERENT KINDS OF PETROLEUM.

Verschiedene Petroleumsorten. A. FAUCK. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1883, *pp.* 331, 332.

Raw petroleum is found in many different conditions, some kinds being almost like tar, and others again quite thin and very inflammable; and the quality of the refined oil depends largely upon its comparative purity when raw. In general, America possesses the best kinds, and afterwards come Galicia, Roumania, Hanover, and Baku in order.

Good lamp oils should be clear and transparent, and have a specific gravity of from ·82 to ·79, and at a temperature of 100° Fahr. they should not give off inflammable gas.

The petroleum in Russia and Roumania is for the most part heavy and poor in quality. In Galicia the quality varies considerably, some being very good, but a large proportion poor.

The sale of petroleum inflammable at 100° Fahr. is in general forbidden in Austria, but a special exception to this rule was made in favour of that from Galicia, it being found that the trade of this district would otherwise suffer very heavily.

A. R. L.

KORTING'S WATER-JET ELEVATOR.

Der Wasserstrahl-Elevator am Rudolfschachte in Bleiberg. EDM. MAKUC. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen,* 1883, *pp.* 332–334. *Illustrated.*

One of these machines has been used since the winter of 1882 in the Rudolf Shaft, at Bleiberg, where it took the place of hand-pumps, worked by eight men per shift of 10 hours, or sixteen men per day of 24 hours. The principle involved is that the pressure on pipes of water flowing through them varies inversely as the speed, and, when the latter reaches a certain point, becomes negative, or, in other words, is converted into suction.

The jet is supplied by a $1\frac{7}{16}$-inch pipe, led down the pit with a head of water of 617 feet. The elevator, which lies in the sump, is about $11\frac{1}{2}$ inches long, and from a diameter of half an inch in the middle widens out towards the ends. At one end it is flanged to a 2-inch upflow pipe to bank, and at the other a funnel connected with the downflow pipe is inserted into it, so as to leave an open space round it, which communicates by a suction pipe with the sump water.

The downward flow is about ·433 gallon per second, at a speed of 6·45 feet per second, and the upward flow is about ·796 gallon per second, the amount pumped being thus ·363 gallon per second. The depth of the mine is about 15 fathoms, and the performance of the elevator is about 12 per cent. It is calculated that the same machine could be used down to a depth of 34 fathoms, when its performance would become 20 per cent. At present the machine works 6 hours per day.

A. R. L.

ON VARIOUS SYSTEMS OF STEAM CARRIAGES IN BELGIUM AND THE RHENISH PROVINCES.

Mémoire sur divers systèmes de voitures à vapeur employées en Belgique et dans les provinces Rhénanes. Par M. WORMS DE ROMILLY, *Ingénieur en chef des Mines. Annales des Mines, Sér.* 8, *Tome V.,* 1884, *pp.* 205–239. *Plates VI. to X.*

In a lengthy and detailed paper, well illustrated, the author describes four systems of steam carriages (or steam trams), pointing out what he considers as the defects of each system and comparing the miles run and number of passengers conveyed. The paper concludes by a summary and table of comparative dimensions, as follows:—

	Delpaire, No. 1 Type.	Terneuzen.	Delpaire, No. 2 Type.	Thomas.
Total length of carriage without buffers	37 ft. 4 in.	46 ft. 3 in.	39 ft. 4 in.	40 ft.
Distance between extreme axles ...	23 ft. 4 in.	34 ft. 9 in.	26 ft. 9 in.	24 ft.
Weight of working carriage without passengers	19 tons.	25 tons.	$21\frac{1}{2}$ tons.	28 tons.
Seats, first class	22	...	10	6
„ second class	...	...	10	35
„ third class	22	69	32	40
Diameter of driving wheels	$38\frac{1}{2}$ in.	37 in.	$38\frac{1}{2}$ in.	$42\frac{3}{4}$ in.
„ cylinders	7 „	8 „	7 „	9 „
Stroke	$12\frac{1}{2}$ „	$12\frac{1}{2}$ „	$12\frac{1}{2}$ „	14 „

D. P. M.

SCHEDULE OF THE ACCIDENTS OCCURRING TO STEAM APPARATUS IN 1882.

Bulletin des accidents arrivés dans l'emploi des appareils à vapeur pendant l'année 1882. *Annales des Mines, Sér.* 8, *Tome IV.*, 1883, *pp.* 574–584.

This paper enters fully into the causes of each explosion, but we need only reproduce for sake of brevity the following table:—

Summary.

I.—BY DESIGNATION OF WORKS.

	No. of Accidents.	No. of Killed.	No. of Injured.
Boats	3	5	2
Laundries	2	2	—
Railways	1	—	—
Preserves, manufactories of	1	1	—
Tools, manufactories of	1	—	—
Distilleries	2	—	—
Cloth, manufactory of	1	—	1
Quarries	1	—	—
Agricultural machines	3	9	6
Spinning mills	1	2	1
Foundries	1	—	1
Motive power, workshop	1	1	—
Forges, workshops of	3	10	5
Oil works	1	2	0
Laboratories	1	—	—
Mine	1	1	—
Minoterie	1	—	1
Animal black, manufactory of	1	1	—
Paper mill	4	3	1
Refinery	1	—	1
Rosin, works for preparing	1	—	—
Sawmills	2	1	—
Sugar, manufactory of	1	1	—
Dyeworks	1	—	—
Contractor's yard	1	1	1
Total	37	40	20

II.—BY DESCRIPTION OF APPARATUS.

(*a.*)—*Boilers externally fired*—			
Horizontal, without tubes	11	7	6
Vertical	3	7	1
(*b.*)—*Boilers internally fired*—			
Horizontal, without tubes	1	3	—
Do. more or less tubular	8	17	8
Vertical	2	—	1
(*c.*)—*Receivers*	9	3	3
(*d.*)—*Sundries*	3	3	1
Total	37	40	20

III.—BY PRESUMED CAUSES.

(*a.*)—*Defective condition of materials*—	
Construction, arrangement, setting, or defective materials	10
(*b.*)—*Defective keep*—	
Wear and tear, deterioration, or thinning	15
Want of, or defective, repairs	7
(*c.*)—*Mismanagement of the apparatus*—	
Want of water (sometimes with addition of sudden and injudicious feed when hot)	5
Over-pressure	6
Other causes of imprudence and neglect	4
(*d*)—*Causes still unknown*	2

NOTE.—The number of "presumed causes" is in excess of the total number of accidents, due to one accident being credited occasionally with more than one cause.

D. P. M.

STATISTICS OF THE PRODUCTION OF MINERALS IN FRANCE.

Statistique de l'Industrie Minérale de la France. Combustibles Minéraux. Annales des Mines, Sér. 8, *Tome V.*, 1884, *pp.* 103–105.

Geographical Situation of Coal Basin.	Output. 1882. Tons.	Output. 1883. Tons.	Typical Basin.
) *Coal and Anthracite*—			
Nord and Pas-de-Calais ...	9,484,021	10,051,461	Valenciennes, etc.
Loire	3,620,550	3,651,860	St. Etienne, &c.
Gard	1,929,717	2,024,448	Alais, etc.
Bourgogne and Nivernais ...	1,543,508	1,585,173	Creusot and Blanzy.
Tarn and Aveyron	1,163,113	1,153,320	Aubin, etc.
Bourbonnais	1,044.764	1,159,796	Commentry, etc.
Auvergne	316,399	340,743	Brassac, etc.
Herault	287,151	315,720	Graissessac.
Vosges Méridionales ...	199,841	202,093	Ronchamp.
Ouest	187,902	181,071	Le Maine, etc.
Greuze and Corrèze	143,060	182,896	Ahun, etc.
Alpes Occidentales	125,970	147,371	Le Drac.
Maures	800	150	Les Maures.
Pyrenees	.....	.....	Durban, etc.
Total coal	20,046,796	20,887,092	
) *Lignite*—			
Provence	502,119	511,050	Le Fuveau.
Comtal	28,313	24,456	Bagnols, etc.
Sud-ouest	14,223	11,114	Millau, etc.
Vosges Méridionales... ...	9,777	10.657	Gouhenans, etc.
Haut-Rhône	2,476	1,830	La Tour du Pin.
Total lignite	556,908	559,107	
Grand total	20,603,704	21,446,199	

D. P. M.

ON THE COAL BASIN OF LANCASHIRE.

Mémoire sur le Bassin houiller du Lancashire. Par M. M. LUUYT, *Ingénieur des Mines. Annales des Mines, Sér.* 8, *Tome V.*, 1884, *pp.* 5–102.

PART SECOND (Page 35).—MODE OF WORKING.

The author of the paper thus commences the second part of the subject, the first having been devoted to the geological features. Lancashire is the most densely-populated county in England, and that in which the railway system has reached its highest development, four main lines connecting the various divisions, viz., the London and North-Western Railway, Lancashire and Yorkshire Railway, Manchester, Sheffield, and Lincolnshire Railway, and the Cheshire lines (Plate I., Fig. 1), traverse the county; and a considerable quantity of coal is conveyed by canal to Leeds, Liverpool, Stockport, Huddersfield, etc., part of the coal produced being used in Manchester and other manufacturing centres, and part exported from Liverpool.

The depth and extent of the coal-mines are noticed, the following being cited:—

			Yards.	Metres.
Ashton Moss Colliery,		Ashton	937 ...	860
Rosebridge	"	near Wigan	811 ...	745
Bickershaw	"	near Leigh	737 ...	647
Abram	"	"	648 ...	595
Clifton	"	near Manchester ...	571 ...	525
Bridgewater	"	" ...	566 ...	520
Bradford	"	" ...	556 ...	510

The extent may be exemplified by the Pemberton royalty, which is 3,300 yards (3,000 metres) across and 3,100 yards (2,800 metres) in vertical depth of coal-measures. The mode of leasing is then explained, as well as the reasons for having so few pits in the large allotments of coal-bearing strata.

The general arrangement is that of two neighbouring pits designated the downcast and the upcast, coal being generally raised in the former, although in many cases the upcast is also available for coal-drawing. Pumping is of little importance in Lancashire, and men are raised and lowered in the ordinary coal-cages. One characteristic feature of the district is the absence of any building enclosing heapstead, pulleys, screens, etc. (as in Belgium and other coal-basins).

When the upcast is used for coal-drawing, it is usually, when ventilated by a fan, covered by a cap or doors, holes being left for the ropes to play. Several examples are given of this mode of utilizing the upcast, such as West Leigh, of the Wigan Coal and Iron Co. (Plate I., Fig. 4), where a 40-feet diameter Guibal affects the ventilation. Abram, with its boxed-in top, and Pemberton, with a nearly similar arrangement, are also described (Plate II., Fig. 1). The mode of walling, tubbing, etc., is then described in detail, several examples of the different systems being given, as well as particulars of cages, pulleys, guides, and all the plant of a complete Lancashire coal-pit.

The various modes of working the coal were also examined by the author, whose preference seems to be for the "long-wall" system. Westleigh, Rosebridge, and Pemberton workings are described minutely.

The coal-getting, use of powder, and compressed air cartridges form the next subject; and then come the hauling systems, endless rope and chain, tail-rope, inclined planes, etc., and examples are given with illustrations; and then details are given of the various winding-machines, dimensions, depth of pit, speed, output, etc.; Rosebridge coming first in speed at 49 feet (15·00 metres) per second, and Westleigh

second at 45 feet (13·60 metres). Conical, spiral, and plain drums are described with dimensions, construction, etc., and the pumping-engines at Outwood, &c., cursorily reviewed.

The question of ventilation is much more fully discussed, and the Guibal ventilators commended in preference to the furnaces, and Mr. Hall's remarks in favour of fans quoted at length. The Bickershaw ventilator (Guibal) is given at 48 feet (14·5 metres), and all the adjuncts, water-gauges, counters, etc., detailed. Boilers, screens, lamps, management, output, accidents, have all special and interesting chapters; and, in conclusion, the writer bases upon Mr. Hall's statistics a conviction that a prosperous future is in store for the district of Lancashire. D. P. M.

NOTE OF AN ACCIDENT WHICH OCCURRED JULY 12TH, 1883, AT THE PIT "DES ROSIERS."

Note sur un accident survenu le 12 *Juillet*, 1883, *au puits des Rosiers* (*concession de Quartier-Gaillard, Loire*). *Annales des Mines, Sér.* 8, *Tome IV.*, 1883, *pp.* 569–573.

On July 12th, 1883, Portes, a stoneman in the Rosiers coal mine, was burnt by a shot under circumstances of some interest. He was employed, as was also a companion, Blanc, in driving a rise drift in the upper level of the eighth seam. This drift was 9 yards (8 metres) long by a little over 3 yards wide, and an average height of 6½ feet.

Powder was used on account of the tough and hard nature of the coal. A hole had been bored ready for firing in the corner of the drift (Plate XVIII., Fig. 2) about 3 feet in depth (1 metre). The weight of powder was 375 grammes (13 ounces), and the stemming about 12 to 15 inches of coal-dust and dirt picked from the floor of the drift. When all was ready the two men retired to the points marked P and B on the plan, while the underviewer remained to light the fuse. The underviewer, after having examined the place with his safety-lamp, and finding it free from gas, lighted the fuse and sheltered in a stenton (J). In a few seconds a violent detonation occurred, while volumes of flame poured against the air current, and burnt Portes, who was stationed round two corners and 11 yards from the mouth of the rise drift. From Blanc's evidence it appears that the flame was red in colour, and contained a number of small particles of ignited matter. It is also to be noted that Portes was burnt on the side next the direction of the shot, and that his head was unhurt, being sheltered by his arm and a headtree of timber.

It was at first thought that fire-damp was the cause of the mass of flame, but the seam had never given off gas, and further examinations and tests showed the improbability of any outburst. The conclusion arrived at was that the shot (which had blown out) had ignited the dust in the drift, and this having raised an eddying cloud in the main level, set fire to this also. To prove this a similar set of conditions was subsequently organized, and the results nearly coincided, and the writer considers this as another instance to be added to the list of explosions of coal-dust from blown out shots.

It is recommended:—

1.—To avoid heavy charges of powder and coal stemmings.

2.—To direct the men to retire to the main level at least 30 yards from the shot when being lighted.

Watering presents practical difficulties, and in the absence of gas may be dispensed with. D. P. M.

EXPERIMENTAL AND THEORETICAL RESEARCHES ON THE COMBUSTION OF EXPLOSIVE MIXTURES OF GASES.

Recherches experimentales et théoriques sur la combustion des mélanges gazeux explosifs. Par MM. MALLARD *et* LE CHATELIER, *Ingénieurs au Corps des Mines. Annales des Mines, Sér.* 8, *Tome IV.*, 1883, *pp.* 379-568.

This paper is too lengthy and detailed to be translated in any but a very concise and general mode; in fact, little more can be effected than a curt notice of some of the most interesting chapters into which the paper is divided.

INTRODUCTION.

Every combustion is attended with a certain exhalation of heat, which raises the temperature of the body in combustion. This temperature to which this said body is subjected is, when isolated from all external causes of variation, termed the temperature of combustion. This is very useful in many cases where the temperature of a given body must be raised to a certain temperature, which temperature can never exceed the temperature of the flame. The temperature of the body in combustion and the temperature of the gases produced by the combustion are proved to vary generally and sometimes considerably, owing to the variation, more or less marked, of the specific heat of the gases resulting.

CHAPTER I.

First Series of Experiments with the Deprez Manomètre.

It was proposed when the Fire-damp Commission made its experiments on the explosive nature of fire-damp, to ascertain the pressure in closed vessels, and to calculate from this the temperature. The want of simultaneous action was against the correctness of the results, and an apparatus was contrived (Plate XII.) to obviate these defects. This, however, still gave erroneous results.

CHAPTER II.

Second Series of Experiments with the self-registering Bourdon Manomètre.

This apparatus is also illustrated (Plate XVIII.), and gave much more exact results, which are illustrated by diagrams and curves (Plates XII. to XVIII.) The mode of calculating these results is also minutely explained, and the cooling down following the combustion is carefully calculated. It would, however, be impossible to give an intelligible summary of these tables in a condensed form, and the only way of obtaining complete information is by examining and studying the diagrams and calculations *in extenso.*

CHAPTER III.

This chapter is a compendium of the entire paper, giving the conclusions arrived at under the following heads, into which it subdivides the subject:—

(*a*)—Laws of cooling in gases.
(*b*)—Dissociation.
(*c*)—Temperatures of combustion with constant volumes.
(*d*)—Specific heats of gases; carbonic acid; steam; pure gases; hydrochloric acid; chlorine.
(*e*)—Temperatures of combustion with constant pressures.
(*f*)—Theoretical considerations.

D. P. M.

COMPARISON OF THE TRANSMISSION OF POWER BY ELECTRICITY AND OTHER MODES IN USE.

Comparaison du Transport de la Force par l'Électricité et des autres transports mécaniques les plus usités. Abstracted by CH. ARENDT, *Ingénieur honoraire des Mines, from the Prize Paper of the Elektrotechniker Verein of Berlin. Revue Universelle, Sér.* 2, *Tome XV.*, 1884, *pp.* 522–533.

The systems mentioned as being the proper agents for transmitting power to long distances are:—

1.—Electricity.
2.—Hydraulic pressure.
3.—Compressed air.
4.—Quick-running ropes.

The elements considered are in each case:—

1.—Cost of power obtained from the motor.
2.—Useful effect.
3.—First cost and wear and tear.

Detailed descriptions of each system are given, and the subdivision of cost carefully considered, the head of electricity being sub-classified as steam dynamos and hydraulic dynamos; but the following summary of the minute tables drawn up by the translator will give an idea of the scope of the paper:—

AVERAGE COST PER EFFECTIVE HORSE-POWER PER HOUR.

	Horse-Power per Hour.	Length in Metres.	Cost in Francs.	Length in Metres.	Cost in Francs.
Electro—					
Steam ...	50	1,000	0·207	10,000	0·284
Hydraulic ...	50	1,000	0·027	10,000	0·032
Hydraulic power—					
Steam ...	50	1,000	0·187	10,000	0·479
Water head...	50	1,000	0·022	10,000	0·079
Compressed air—					
Steam ...	50	1,000	0·227	10,000	0·363
Water head...	50	1,000	0·029	10,000	0·067
Ropes—					
Steam ...	50	1,000	0·135	10,000	0·470
Water head...	50	1,000	0·012	10,000	0·075

The conclusions drawn are mostly in favour of electric transmission, unless in mines where fire-damp might occur and be subject to ignition by the sparks of the dynamo. Ropes are liable to the objection of not being easily applied where much subdivision is required; and compressed air and electricity both appear to have the advantage in subterranean work. The former must evidently be more economical in wear and tear. This paper is well worth the attention of engineers interested in the subject, and the details are most carefully examined and explained. D. P. M

REPORT BY THE SUB-COMMITTEE ON SUPERHEATED WATER.

Rapport présenté à la Commission Centrale des Machines à Vapeur, au nom de la sous-commission chargée des études et expériences relatives à l'eau surchauffée. Par M. HIRSCH, *Ingénieur en chef des ponts et chaussées. Annales des Mines, Sér.* 8, *Tome V.*, 1884, *pp.* 171–204.

In a paper presented last year by Commander Trève to the Académie des Sciences, on the prevention of boiler explosions, reference was made to the frequent occurrence of what was known as superheated water, and the above sub-committee, of which M. Hirsch was a member, was appointed to investigate and report on the subject.

M. Trève's theory was first examined. His view was that when water was in ebullition for a length of time the air was driven out of it and the temperature was raised some 80° or 90° above boiling point, and he gives in corroboration cases where no steam has been drawn from the boiler during the night, and when disturbed on resuming work violent explosions occurred.

The duties of the sub-committee were to examine and report on the conditions producing superheating and the means of prevention or neutralisation.

The conclusions arrived at by them were divergent from those of M. Trève, and are summarized at the end of an elaborate and interesting series of experiments on different vessels (Plates IV. and V.) as follows :—

"It has not as yet been shown that superheating of the water in any boiler has been the cause of explosion. If such should have occurred it must have been through an agglomeration of circumstances coincident, exceptional, and at present unknown. It is therefore useless to examine the value of any of the proposed remedies; and it is proposed that an instrument to register the temperature of the water and the saturation of the steam, might be properly employed to arrive at precise data relative to this indefinite and unknown condition of water in a boiler."

The Central Commission adopted the report of the sub-committee. D. P. M.

ORE-DEPOSITS OF LEADVILLE, COLORADO.

Geology and Mining Industry of Leadville, Lake County, Colorado. By S. F. EMMONS. *Second Annual Report of the United States Geological Survey, Washington*, 1882 (*issued* 1883), *pp.* 203–290. *Plates XLIV., XLV.*

This is a lengthy preliminary abstract of an exhaustive monograph not yet published.

Leadville stands on the western flank of the Mosquito or Park range, on the eastern slopes of the Upper Arkansas Valley. It is about 10,000 feet above sea-level, but the peaks of the surrounding mountains rise above 14,000 feet. The sedimentary rocks of the region are (in ascending order) as follows :—

1.—*Archæan Rocks*—

Granites, gneiss, and hornblende rocks (amphibolites) of various kinds, all metamorphic. These rocks form the old core of the Rocky Mountains, and in that part of the Continent of America correspond to the Laurentian deposits of the Eastern States. In many cases they have never been submerged since Cambrian times. Thickness unknown.

2.—*Cambrian*—

Lower Quartzite, white, passing into limestone and shales above. 150 to 200 feet.

3.—*Silurian*—

(*a*) *White Limestone*, with chert. 200 feet.

(*b*) (above the limestone) *Parting Quartzite*, white. 40 feet.

4.—*Carboniferous*—

(*a*) *Blue Limestone*.—Compact, dolomitic, cherty above. These are the ore-bearing rocks *par excellence*. 200 feet.

(*b*) *Weber Grits*.—Coarse white sandstones, with conglomerates, micaceous shales, and occasional thin beds of limestone. 2,500 feet.

(*c*) *Upper Coal-Measure Limestone*.—Blue and drab limestones and dolomite, with red sandstones and shales, mud shales at top. 1,000 to 1,500 feet.

5.—*Quaternary*—

(*a*) *Lake Beds*.—Fresh-water locustrine deposits.

(*b*) *Recent Formations*.—Including glacial drift, moraines, etc.

The igneous rocks are Mesozoic porphyritic, basic, and acidic rocks of various kinds, of which one, the "white" or "Leadville" porphyry, is a normal quartz porphyry intimately connected with the ore-deposits. It is locally known also as "block porphyry" and as "forest rock," and occurs chiefly south of an east and west line drawn through Leadville.

The author states that his investigations have proved (page 234) :—

I.—That the ore-deposits of Leadville have been derived from aqueous solution.

II.—That these solutions came from above.

III.—That they derived their metallic contents from the neighbouring eruptive rocks.

IV.—That in their original form they were deposited not later than the Cretaceous epoch.

V.—That the metals were deposited from their solutions mainly as sulphides.

VI.—That the process of deposition of the vein-material was a chemical interchange, or actual replacement of the rock-mass in which they were deposited.

VII.—That the mineral solutions or ore-currents concentrated along natural water-channels, and followed by preference the bedding planes at a certain geological horizon; but that they also penetrated the mass of the adjoining rocks through cross-joints and cleavage planes.

VIII.—That the main mass of argentiferous lead ores is found in calcareo-magnesian rocks; and

IX.—That the siliceous rocks, porphyries, and crystalline rocks contain proportionately more gold and copper.

The principal ore-deposits occur near the contact of the Carboniferous *Blue Limestone* with the overlying porphyry in a gangue of iron, manganese, and clay. The prevailing ore is argentiferous galena, with its secondary products, lead carbonate and silver chloride. Sulphate (anglesite) and phosphate (pyromophite) of lead are also found. Gold occurs native, in very small flakes or leaflets. Zinc blende, calamine, with arsenic and antimony minerals also occur, together with sundry others.

A coloured geological map on a scale of ½ mile = 1 inch, and a sheet of illustrative sections, illustrate the present paper. The forthcoming complete memoir will, however, be accompanied by a large atlas of many maps, plans, and sections. A short metallurgical report, by Mr. A. Guyard, is given in abstract (pp. 285–290).

G. A. L.

THE WESTPHALIAN COAL-FIELD.

Congrès annuel tenu à Dortmund, les 13, 14, 15, *et* 16 *Août*, 1883, *par l'Association générale des Ingénieurs Allemands. By* PH. PASSELECQ, P. LEBACQZ, and A. STOESSER. *Publications de la Société des Ingénieurs sortis de l'École provinciale d'Industrie et des Mines du Hainaut, Sér.* 2, *Vol. XV.*, 1884, *pp.* 64–98, *large folding Map and Section. Plate VII.*

This is the official report of a four days' visit to the principal collieries and works of the Westphalian coal-field. A small longitudinal section, showing the lie of the beds between Recklinghausen and Sprockhövel, and a vertical section on a larger scale, showing all the coal-seams, shales, sandstones, and conglomerates of the district, are given. The greater portion of the report consists of brief notes giving useful statistical information (*e.g.* nature of coal, depth of shafts, output, kind of pumping and ventilating machinery in use, etc.) respecting the following colliery concessions:—Alstaden, at Oberhausen; Germania, at Müllenseifen; Minister Stein, near Dortmund; Westphalia, at Dortmund; Fröhliche-Morgensonne, at Wattenscheid; Dahlbusch, at Rothausen; Bonifacius, at Wattenschied; Langenbrame, at Essen. Some account is also given of the metallurgical works of the Dortmund Union (*Union, Actien Gesellschaft für Bergbau, Eisen und Stahl-Industrie, Dortmund*), of the Hoerde Campany *Hoerder Bergwerks und Hüttenverein, zu Hoerde*), of the Bochum Company (*Bochumer Verein für Bergbau und Gusstahlfabrication*), and of the Hoesch steel works at Dortmund (*Eisen und Stahlwerk Hoesch, zu Dortmund*).

G. A. L.

THE GEOLOGICAL SURVEY OF BELGIUM.

(1) *La carte géologique détaillée de la Belgique à l'échelle du* 1 : 20,000. (2) *Sur l'utilité de la carte géologique de la Belgique à l'échelle du* 1 : 20,000. *By* A. RUTOT. *Revue Universelle des Mines, Sér.* 2, *Vol. XV.*, 1884, *pp.* 295–335. *Three Figures in text.*

The first of these papers gives a full account of the methods followed in drawing up the large scale (1 : 20,000) Government Geological Map of Belgium. The map will consist of 432 sheets, of which the following have already been published (up to 1st March, 1884), viz.:—Ciney, Natoye, and Dinant, with diagrammatic sections and explanatory text. Many other sheets with accompanying memoirs are nearly ready, viz.:—Hastières, Clavier, Modave, Bruxelles, Bilsen, Landen, St. Trond, Heers, Virton, Ruette, Lamorteau, Achêne, Rosée, Philippeville, Senzeilles, Sautour, and Hamoir. In colouring the maps a distinction is made between those parts of the outcrops which are actually visible at the surface and those which are concealed by soil, etc., and the subdivisions of the Post-Tertiary and Recent deposits, which occupy so large a portion of Belgian territory, are shown simultaneously (and, it is said, without loss of clearness) with those of the underlying rocks. The process by which the latter object has been attained is technically known to the officers of the survey as "*fusion du sol et du sous-sol*," and as a result the maps thus coloured are good agricultural as well as geological maps. The orographical features of the country are shown by contour-lines 5 metres apart on the left side of the Meuse, and 10 metres apart on the other side.

The second paper points out the special advantages of the new map from industrial, agricultural, and hydrographical points of view.

The entire cost of the survey is estimated at 2,000,000 francs (£80,000), and seventeen years are allowed for its completion.

G. A. L.

THE COMSTOCK LODE.

A Summary of the Geology of the Comstock Lode and the Washoe District. By GEORGE E. BECKER. *Second Annual Report of the United States Geological Survey, Washington*, 1882 (*issued* 1883), *pp.* 293–330. *Plates XLVI., XLVII.*

This again is a preliminary *résumé* of results, based upon details to be published in an elaborate report now in the press. The Comstock Lode lies in a desert country forming a north-easterly spur of the Sierra Nevada, and known as the Virginia Range. Mines were first opened upon it in 1859, and since that time to 1880 they have produced 315,000,000 dollars worth of bullion, of which 175,000,000 dollars was silver. At the latter date the number of men employed was 2,770, the length of shafts and levels more than 150 miles, and the greatest depth above 3,000 feet.

The author examines and criticises the views of Baron von Richthofen and Professor Church respecting the phenomena of the region. The rock named *Propylite* by the former has, he states, no real existence. It is merely the decomposed form of several kinds of greenstone. The great heat of the Comstock Lode, regarded by Professor Church as being due to the kaolinization of felspar, is referred by Mr. Emmons to a source more than two miles below the surface, and connected with the hot-springs and gases of dying-out volcanic action. In fact, in his view, the immediate neighbourhood of the lode is an almost extinct solfatara.

The country on either side of the lode consists of highly metamorphic and igneous rocks of various kinds, and it is where diabase forms the hanging-wall and diorite the foot-wall that all the great accumulations of ore (bonanzas) have hitherto been found. This point is thought to be important in following the lode in new ground.

The summary concludes with brief accounts of experiments carried out for the author by Dr. Barus (1) "On kaolinization and the amount of heat to which it gives rise," and (2) "On the electrical activity of ore bodies."

Plate XLVI. is a coloured geological map of the Comstock region on a scale of 1 inch = 1,500 feet. Plate XLVII. gives a partial section of the Washoe district along the Sutro Tunnel line. G. A. L.

THE LANCASHIRE COAL-FIELD.

Mémoire sur le Bassin Houiller du Lancashire. By M. LUUYT. *Annales des Mines, Sér.* 8, *Vol. V.*, 1884, *Geological Part, pp.* 7–34. *Plate I. (in part).*

After describing the Carboniferous rocks of the Lancashire coal-field, after Hull and others, the author devotes some pages (pp. 30–34) to the Permian and Triassic rocks of the district, and discusses the question of the possible extent of concealed Coal-Measures. He points out that, according to Strahan, the Permian series is wanting beneath the Trias in South Lancashire, West of Warrington. He concludes that it is improbable that the upper coal seams, should they be proved to exist beneath the Trias, will be easily won, and that in no case will the coal-field on the right bank of the Mersey be opened out on a large scale until the rest is worked out.

In the course of the paper summarized sections of the coal-seams and other strata at the following places are given:—Ashton and Hartshead, Wigan (Middle Coal-Measures), St. Helen's, Manchester, Patricroft, Burnley, Bold Hall Colliery (1875–78), Collins Green Colliery, Haydock Colliery, Farnworth, Parkside, and Winswick.

G. A. L.

VARIOUS ANALYSES.

Bulletin des Travaux de Chimie exécutés en 1882 *par les Ingénieurs des Mines dans les Laboratoires Départementaux. Annales des Mines, Sér.* 8, *Vol. V.*, 1884, *pp.* 123–161.

Among the analyses here recorded as having been made by the Departmental laboratories of Angers, Clermont-Ferrand, Limoges, Le Mans, Marseilles, Privas, Rennes, and St. Etienne, the following are of mining interest:—1.—Iron ores (brown hæmatite and carbonate of iron), from the St. Laurs mine, in Loiret. 2.—Coals, from new localities in the Commune of Youx. 3.—Antimonite, from Montrôme (Haute-Loire) and Langeac. 4.—Phosphate of lime, from various localities. 5.—Coals, from Cardiff and the Alais coal-field. 6.—Lignites, from various localities in the Basses Alpes. 7.—Coals, from the Banne coal-field. 8.—Lignite, from the "Minerve" Mine (Herault). 9.—Galena, from the Salet lode (Puy-de-Dôme). 10.—Iron ore, from the Toussieux boring (Isère) at a depth of 273 metres (895·7 feet).

The results from the Algerian laboratories comprise:—1.—Lead ores, from Tizi-Ouzou, Djidjelly, Beni-Messaoud, Aoucha, Ouled-Abdallah, Saïda, and Embarka. 2.—Zinc ores, from Tizi-Ouzou, Ouarsenis, and Ouled-Zied. 3.—Coal, from Bou Saada. 4.—Copper ores, from the Oued-Missia basin. 5.—Iron ores, from Filfila (Manganesiferous brown hæmatite), and Tazont (red hæmatite). G. A. L.

UNDERGROUND TEMPERATURE AND TUNNELS.

(1) *Le Percement des Tunnels et la Chaleur souterraine. By* G. Revaux. *Annales des Mines, Sér.* 8, *Vol. IV.*, 1883, *pp.* 605–610.

Applies Stapff's formulæ (see Transactions of the North of England Institute of Mining and Mechanical Engineers, Vol. XXXIII., p. 19) to the proposed Simplon and Mont Blanc Tunnels, and shows that in the former, which is to be nearly thirteen miles long, a maximum temperature of 95° F. is to be expected. In the case of Mont Blanc, where the tunnel will be between eleven and twelve miles long, the temperature will, it is calculated, be over 86° F. for more than half the distance, and will probably reach a maximum of 122° F.

(2) *Erdwärme und Tunnelbau im Hochgebirge. By* Dr. Gustav Koch. *Zeitschrift des Deutschen und österreich-Alpenvereins, Vol. XIII. pp.* 69–80.

The author states that the isothermal lines beneath mountains are not only relatively but absolutely deeper than under plains or valleys, and he illustrates this view by a diagram.

(3) *Der Verlauf der Geoisothermen unter Bergen. By* Dr. August Böhm. *Verhandlungen der k.k. geologischen Reichsanstalt, Ann.* 1884, *pp.* 161–164. *Two Figures in text.*

A criticism of the last paper, showing Dr. Koch's error. The rate of increase of temperature is slower beneath mountains than under valleys or plains; but the isotherms, though farther apart than in the latter case, rise within mountain-masses, and are therefore often much higher—so far as absolute level is concerned—than the surfaces of the plains at the mountain foot. The increase in depth of isotherms beneath mountains is, in fact, relative only, and not absolute, as Dr. Koch imagines. The author quotes Stapff, Supan, and Günther in support of the ordinary view.

G. A. L.

EAST AFRICAN COAL.

(1) *Note sur le Bassin Houiller de Tete (Région du Zambèze).* *By* E. LAPIERRE. *Annales des Mines, Sér.* 8, *Vol. IV.*, 1883, *pp.* 585–593. *Plate XIX.*

Account of a geological exploration carried out in the region about Tete, on the Zambesi River, in 1881, by the author and others. A very large coal-field (or possibly a number of detached coal-fields) occur in the country comprised between the Zambesi, Rovugo, Moatise, and Muarose rivers, and beyond that area. Its extent could not be determined. Coal was found in several seams varying in thickness from 30 centimetres (1 foot) to 14 metres (46 feet). The rocks accompanying the seams are of the ordinary Coal-Measure type, and seldom dip more than 10° or 12°, except when close to eruptive masses of greenstone, which are not uncommon in the country. The coal is described as yielding a fairly good coke, with 22 to 25 per cent. of volatile matter. It burns with a long clear flame. There is little or no iron pyrites, and the ash is in consequence white. It is also very abundant (12 to 15 and even 18 per cent.)

Sketch-maps and sections accompany the paper.

(2) *Note sur la Flore du Bassin Houiller de Tete (Région du Zambèze).* *By* R. ZEILLER. *Op. sup. cit., pp.* 594–598.

Describes the coal-plants collected by M. Lapierre. All belong to European Coal-Measure species, and together form a florula (there are but eleven species) similar to those of the Upper Coal-Measures of the basin of the Loire. G. A. L.

GEOLOGY OF THE HARTZ.

Étude sur les éruptions du Hartz. *By* M. TERMIER. *Annales des Mines, Sér* 8, *Vol. V.*, 1884, *pp.* 243-364. *Plate XI.*

An elaborate stratigraphical and petrological account of the igneous rocks of the Hartz, chiefly after Dr. Lossen. The mineral deposits associated with these rocks are also described. Subordinate to the diabases are five kinds of ferruginous deposits, all occurring at or near the contact of the diabase and the underlying Devonian *Stringocephalus* beds. These, the iron ores of Elbingerode, are the result, the author thinks, of hydrothermal action at the close of the *Givetian* era. The following are the varieties mentioned:—

1.—A limestone altered for a considerable thickness, so as to contain as much as 50 per cent. of iron.

2.—A tufaceous ore, somewhat calcareous, but always very siliceous also, resting on the limestone and passing gradually into diabase (*schaalstein*). Sometimes this yields 60 per cent. of iron. This is, commercially speaking, the most important ore.

3.—An ore due to the decomposition of a pyritous rock intimately associated with an albite porphyry.

4.—A jaspoid ore, containing much quartz and anhydrous sesquioxide of iron, always overlying the albite porphyry, and underlying sometimes the schaalstein, sometimes limestone.

5.—Granular brown hæmatite, evidently of sedimentary origin. G. A. L.

MANGANESIFEROUS IRON ORES OF RANCIÉ.

Étude sur la teneur en Fer et en Manganèse des Minerais de Rancié (Ariège). By M. CARCANAGUES. *Annales des Mines, Sér.* 8, *Vol. V.*, 1884, *pp.* 115–122.

The author's object is to find the average percentage of iron and manganese in the ores (chiefly brown hæmatite) of Rancié, in Ariège, with special reference to the relation between the richness of the ore and the state of fragmentation in which it is extracted from the mine. The mode of sampling adopted is described, and tables of the results are given. These show very clearly that as the ore gets smaller the percentage of iron diminishes, whilst the proportion of manganese generally increases. This is explained by the small degree of coherence possessed by the manganese oxides. The final results are shown in the following table:—

Size of the Ore.	Moisture.	Iron.	Manganese.
Coarse	3·52	53·28	3·47
Medium	3·38	50·10	4·47
Fine	3·32	41·56	5·98
Very fine	3·72	37·84	5·98

The average percentage of iron and manganese (corrected for *dry* ore) were 52·85 and 4·13 respectively. G. A. L.

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"Abs." *signifies Abstracts of Foreign Papers at end of the volume;* "App." *Appendix.*

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